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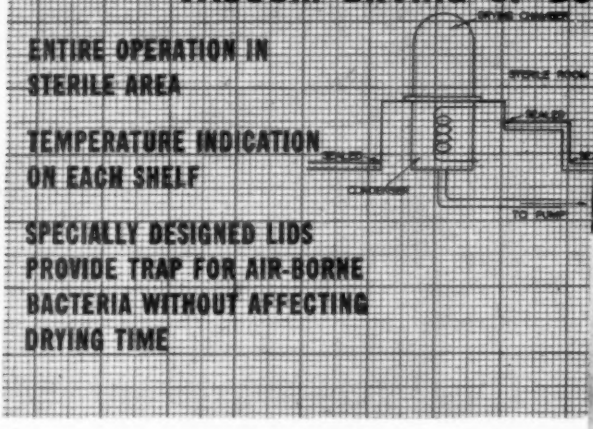

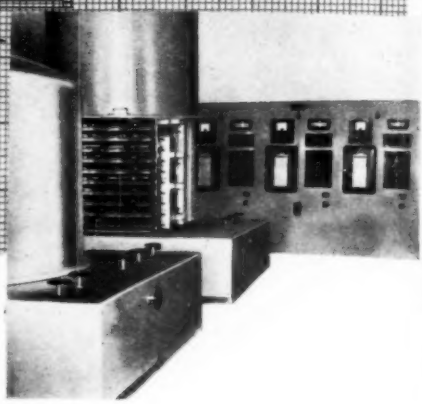

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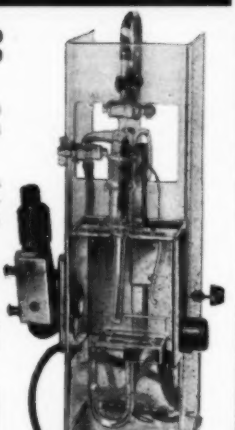

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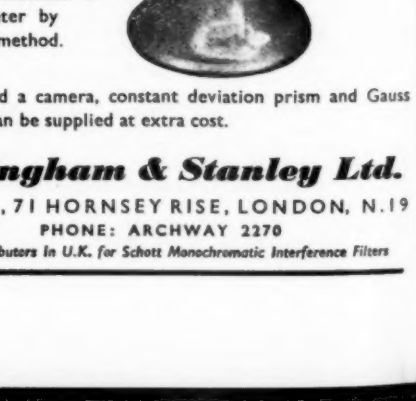

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FREEDOM IN ACADEMIC RESEARCH

In a recent address given in the University of Nottingham, Sir William Slater, secretary of the Agricultural Research Council, made a strong plea that universities should lead rather than follow contemporary thought, and in particular that they should be sufficiently independent financially to be able to allocate sufficient funds for research on lines of work entirely of their own choosing. Sir William was discussing the relative values of such research and of sponsored research, undertaken with the assistance of outside bodies, and he was firmly of the opinion that those carrying on research work in universities should have the freedom to decide whether they would pursue lines of work entirely of their own choosing, within the funds at their disposal, or whether they had problems to put to bodies, such as the Agricultural Research Council, for short-term assistance. The problem of course arises out of the extent to which the universities are now dependent on public funds, and how far, even with the University Grants Committee, it is possible for their independence from outside pressure to be fully maintained.

This was the subject of Prof. W. H. Linnell's address as chairman to the British Pharmaceutical Conference at Newcastle upon Tyne. Starting with the proposition that Britain's most valuable raw material is its young people, to whom education is of paramount importance if they are to develop the knowledge and powers of leadership which alone will ensure the country's survival as an important power, Dr. Linnell emphasized that the interdependence of education and research in science is fundamental. Further, whether or not Britain maintains her position in the world as a great power will depend, he said, largely on her research activities in the near future. These cannot exist unless we possess personnel capable of extending the boundaries of knowledge, and this, in its turn, depends on the education of the young and on some directive influence on their potential.

Against this background, and that of the economic threat developing behind the Iron Curtain, in consequence of the rapid expansion of scientific and technological education and research in the U.S.S.R., Dr. Linnell advanced his plea that academic freedom constitutes a fifth freedom to be set in importance along with President Roosevelt's four freedoms —freedom of speech and expression, freedom of worship, freedom from want, and freedom from fear. Moreover, powerful forces are working against academic freedom in many parts of the world, and these should be resisted at all costs. In particular, he referred to secrecy, especially in regard to publication of research. Secret work of any kind has no place in a university except during an emergency.

In establishing his thesis that our position in the world may well depend upon the fundamental research effort of the immediate future, Dr. Linnell followed in some respects Sir George Thomson's argument in his presidential address to the British Association, deprecating the evaluation of research solely by its contribution to modern living. He was, however, more concerned with the educational aspect—both with the need for greater expenditure on education and with the question of quality, particularly that of an adequate general education, though he recognized that it might be necessary also to encourage an increasing number of students into scientific and technological fields. The colleges of technology as well as the universities have their part to play in providing an adequate body of workers capable of original thought and possessed by a burning desire to extend the frontiers of knowledge.

Given, however, an adequate supply of research workers of the requisite quality, the question of the distribution of the research effort of Britain remains. Even the balance between fundamental and applied research is not easy to determine, and while Dr. Linnell urged that the larger industrial organizations should accept some responsibility for fundamental research in appropriate fields, he did not go into the question of the distribution of research effort as between the universities, independent research institutions, the research associations, Government research stations or departments and industry itself. This question of distribution, however, is quite as important as what Dr. Linnell describes as the basic problem of how to plan our research effort without detriment to intellectual freedom, and indeed its wise handling could go far to remove many dangers to academic freedom. Apart from this, the question of distribution is related to that of the effective utilization of the results of research.

In emphasizing that while it is impossible to plan discovery, it is quite possible to plan for it, Dr. Linnell suggested that more could be done within the universities to ensure that the existing potential for research is utilized in projects that are really worth while. Research within the universities, it is true, serves at least two different, but allied, functions, and this is equally true of research in the colleges of technology, where perhaps expert guidance is particularly needed if they are to make a serious contribution to the research effort. Moreover, the educational objective—both in respect of the teacher and the students he is training—is the more readily achieved if the research effort is itself directed at some objective really worth while.

Dr. Linnell clearly recognizes the difficulty of supplying any such guidance from outside without trespassing on academic freedom, and the Committee on Science and Freedom has evidence enough of how easily academic freedom is infringed even in countries like Canada and Australia. Dr. Linnell's own suggestion is for the universities themselves to set up separate science committees for each scientific discipline to advise on all matters concerning research.

He visualizes such committees acting as clearing houses for ideas, with contacts with research associations and other bodies, and arranging opportunities for people working on similar projects to meet; his suggestion is essentially an extension of what is already being done by the Council for Scientific and Industrial Research and the Medical Research Council, though all the arrangements would be in the hands of the universities.

Nevertheless, if we are to make the best use of the limited resources of scientific man-power in Britain, as Dr. Linnell intends, the Minister for Science must play some part. This is as essential if sufficient financial resources are to be available for research as it is in securing that such man-power is not wasted for lack of either equipment or supporting technicians or through excessive overlapping. Co-ordination is probably best effected by such informal arrangements as the Research Councils are already establishing and the University Grants Committee may also seek to foster; but if public support on the scale visualized by Dr. Linnell is to be secured, the full influence of the Minister for Science and the Advisory Council on Scientific Policy will be needed.

This will be no less essential in the campaign of public education for which Dr. Linnell calls. The scientist himself has indeed an essential part to play in educating public opinion so as to secure adequate support for research, and so also have bodies such as the Parliamentary and Scientific Committee. Finance, however, is only a part of the problem, and in securing the most effective use of scientific and technical man-power, as is indicated by Sir Lindor Brown in a Sir David Russell Memorial Lecture delivered before the University of St. Andrews on March 9, 1960, scientists must themselves exert an important influence.

Under the title "The Perils of Leadership in Science"*, Sir Lindor discussed some problems which bear closely on the quality and effectiveness of university research, and his unusual approach directs attention to factors determining the utilization of trained scientific man-power which are sometimes overlooked. In the main, he is concerned with teachers and research workers in the experimental sciences and those near to them in interest and activity, and at the start he points out that the use of the military analogy in describing the technique of promoting scientific advance can be misleading. Rarely is it possible in scientific strategy to define an objective within the reach of a life-time, and very rarely is such an objective attained.

Sir Lindor Brown's thought runs on the lines of the Barlow Report on scientific staff, now largely forgotten, and he thinks that too little is made of the needs of the scientist for inspiration, and of the quality of a work of art that good scientific work possesses. Sir Edward Appleton, of course, has emphasized this aspect, but Sir Lindor discusses its bearing on fundamental research work, in which he suggests there are three major decisions of strategy to take: what to start, when to stop and where to go, and in that order. Leadership, he suggests, consists essentially in the supply of inspiration, and he is convinced that the British Isles still have a unique supply of original minds and can offer unique opportunities for their cultivation and development.

It is in regard to the starting of a project that the young research worker, he suggests, nearly always needs guidance, and that the real qualities of leadership of his science are fully tested only when, after the younger man has started work on his problem, he has an idea of his own. The treatment of that idea may make all the difference to the younger man's future career, and Sir Lindor stresses the importance of taking every care to avoid damaging what should be the most profitable feature of a scientist's life, namely the free interchange of ideas and argument. Sympathy and imagination, however, are equally required in helping the young worker to deal with the second difficulty, that of knowing where to stop and when to publish his results. In many fields research is more or less a continuous process, and even the experienced worker does not find it easy to take alone the decision when to publish.

Sir Lindor was concerned to emphasize the necessity of publication to complete the research process, and while this has an important bearing on the question of secrecy and academic freedom, his remarks about the continuous nature of such research and the difficulty of setting a clear objective direct attention to an aspect that has to be considered in determining the distribution of our research effort on the broadest scale. It indicates one reason why the maximum of choice must be left to the research worker himself, and recent reports from the Council of Scientific and Industrial Research show that it is a difficulty of which the Council is deeply conscious. If only for the personal effects and the bearing of such decisions on the whole atmosphere in which work is done, as much flexibility as possible is clearly desirable. Enthusiasm once really dampened is seldom easily re-kindled.

The third aspect, that of deciding where to go, is closely related to the second. The attractive vistas continually opened up as work proceeds on a problem set a series of difficult decisions in which even the most experienced scientist may make the wrong choice. The opportunity for wise and enlightened leadership is unmistakable, but even so the leader may take an incorrect decision and the effect on his team may be disastrous unless the right atmosphere already exists. Space, facilities, adequate finance, freedom from petty worries, either domestic or administrative, adequate recognition, someone to give a measure of encouragement at more serious moments of frustration or despondency, perhaps also, as Sir Lindor Brown suggests, some alternative activity, as a little teaching, to stimulate the mind, all have a part to play; and if there is a leader whose wisdom and understanding have already won

* The Perils of Leadership in Science. By Prof. Sir Lindor Brown. (Sir David Russell Memorial Lecture No. 2, delivered before the University of St. Andrews at Queen's College, Dundee, 9 March, 1960.) Pp. 20. (London: Oxford University Press, 1960.) 3s. 6d. net.

the confidence of his colleagues, the essential conditions should be there to ensure that creative work is not thwarted by the inevitable mistakes in human judgment. Seldom, he recognizes, can the head of the laboratory claim sufficiently detailed knowledge to give more than general advice to his colleagues on their scientific problems; but if in good time he can detect the faltering of genius, or an alternative activity of promise, and secure its adoption without causing resistance and revulsion, a laboratory director has discharged one of his most important functions.

Nothing is more important, however, in Sir Lindor Brown's address, than the stress he lays, in conclusion, upon the human demands made on leadership in scientific activity. It is a continuous process, intimately linked with that process of free discussion and criticism which is the essence of scientific advance, and Sir Lindor's own experience leads him to stress the importance of the research director himself working in the laboratory to maintain sympathy and close contact with his staff. He admits the desperate seriousness of the problem of time, but maintains unhesitatingly that to preserve our originality of approach, our capacity for unexpected discovery, and our unconventional freshness of ideas, in which we stand alone, we need leaders who will lead in the laboratory, leaders with sympathy and understanding for the man on the job and leaders with the humility of the true scientist.

That needed to be said, and should be marked in the universities and in Government departments and organizations as well as in industry. Unless those conditions are observed, we shall undoubtedly fail to make full use of whatever scientific and technological man-power is at our disposal, and above all in research. To ensure that such conditions are generally to be found is one of the most economic ways of expanding our existing research effort, but to achieve it may well demand some hard and constructive thinking about problems of administration. Sir Lindor is well aware of the increasing administrative burdens which are being placed on the heads of research units and departments in the universities, in the Government service and in industry, burdens which can scarcely be reduced to-day, however flexible our organization, except by sharing them more widely. That in turn requires a growing supply of scientists and technologists capable of assuming such responsibilities. From that point of view alone it is encouraging to note that in his presidential address to Section B (Chemistry) at the recent British Association meeting at Cardiff, Dr. James Taylor lent the weight of his own experience as a director of Imperial Chemical Industries, Ltd., to what Prof. T. L. Cottrell had said in his inaugural lecture at the University of Edinburgh last autumn as to the need for the universities to ensure that they gave their students not simply a good general education, with all that that implies as to an imaginative approach to human problems, but above all inculcated a critical and intellectual approach to whatever problems confronted them. The effective deployment of our limited resources for research and development demands indeed sound organization constantly kept under review by wise and imaginative administrators: it depends, in particular, on the quality of the man-power available, for the prosecution of research and for the handling of the myriad problems of co-ordination and co-operation, inspiration and guidance on which Sir Lindor Brown touched with vision and understanding.

THE STUDY OF SUB-ATOMIC PHENOMENA BY THE NUCLEAR EMULSION

The Study of Elementary Particles by the Photographic Method

An Account of the Principal Techniques and Discoveries illustrated by an Atlas of Photomicrographs. By C. F. Powell, P. H. Fowler and D. H. Perkins. Pp. xvi+669. (London and New York: Pergamon Press, 1959.) 250*s*. net.

THE study of sub-atomic phenomena, and in particular of the elementary particles, has been much aided by three techniques, the cloud chamber, the photographic emulsion, and the bubble chamber, by which the tracks of individual charged particles can be made visible. This volume is the third of a series designed to present carefully selected photographs of high technical quality to help students to acquire a better understanding of the physical principles involved in sub-atomic phenomena. In these volumes there are reproduced not only those photographs which have made history but also a sufficiently wide range of others to illustrate the power and limitation of the different techniques, and to serve as exercises in the recognition and interpretation of the nuclear phenomena produced by cosmic rays or artificially produced high-energy particles. The first volume, by the reviewer and J. G. Wilson, which appeared in 1952, and the second, by W. Gentner, H. Maier-Leibnitz and W. Bothe, published in 1954, were concerned with the application of the Wilson expansion chamber to cosmic rays and nuclear physics. The present volume covers the application of the photographic emulsion technique to the investigation of the elementary particles and cosmic rays. In common with the companion volumes, the photographs are central and the text is written around them, but unlike the previous volumes the text here is so extensive that the book has become a monumental work on the emulsion technique.

There are good reasons why the present time is opportune for such a work. The first reason is that with the advent of the bubble chamber and the production of beams of the new particles at the great accelerators, the period during which the emulsion technique has occupied a unique place in the study of the elementary particles is drawing to a close. The second reason is the growing confidence that, as the authors state in the preface, "most of the particles which play an important part at that level of penetration into the structure of matter which our present technical resources allow, have either been discovered, or their existence anticipated".

The nuclear emulsion makes possible the precise identification of most of the charged elementary

particles by virtue of its unusual power of discrimination and high stopping power. Its property of continuous sensitivity makes possible the accumulation of rare particles and 'events'. The emulsion is, however, not a very powerful technique for the study of the neutral unstable particles because of the lack of time correlation; and its chemical complexity can cause ambiguity in interpretation. The newly developed bubble chambers seem to combine most of the desirable features of both the nuclear emulsion and the Wilson chamber (apart from cost!), and, moreover, can operate at a speed appropriate to the rapid pulse-rate and high background of the great accelerators. Nevertheless, the nuclear emulsion technique still seems to be the technique most suited to the study of ultra-short-lived particles, in consequence of the extreme fineness of the photographic grain, and of certain aspects of the interaction of cosmic-ray particles of very great energies.

The book opens with a well-documented and illustrated history of the use of the photographic emulsion in nuclear physics and the steps which led to the production of the nuclear emulsion. There follow excellent sections on the basic technical features of emulsions, the range-energy relations, and the measurement of specific ionization and scattering, quantities of considerable importance in the emulsion technique. These sections are beautifully written and illustrated, and will be of great value in the training of research workers. Most of the rest of the book is concerned with the elementary particles, electrons and photons, μ-mesons, π-mesons, K-mesons, hyperons, protons and antiprotons; but there are also quite long sections devoted to hypernuclei, interactions in the energy-range 10^8–10^9 MeV., and heavy nuclei in the primary cosmic radiation. Fundamental discoveries made by use of the technique, for example, the π- and τ-mesons, heavy primaries and hypernuclei, are fully described, and with the original photographs serve as a reminder of the achievements of British physicists in the exciting early post-war years. In all there are 190 plates, superbly chosen and reproduced, and numerous excellent figures to illustrate the text. The text is a clear account of many of the technical aspects of the use of nuclear emulsion in the high-energy field and of modern high-energy nuclear physics. There are a few small errors, but on the whole the book is singularly free from error.

This magnificent volume can be most warmly recommended to anyone interested in nuclear physics, and is a worthy tribute to the part played by the nuclear emulsion technique in the study of the elementary particles. It is also a brilliant tribute to the research school of which the authors are distinguished members. G. D. Rochester

ORIGIN AND DEVELOPMENT OF LIFE

You and the Universe

By Dr. N. J. Berrill. Pp. viii+215. (London: Dobson Books, Ltd., 1959.) 18*s*. net.

Prof. N. J. Berrill has produced a tantalizing book. In it he sets out to show the origin of life, the way it has developed and the place it holds in an evolving universe.

The task is not beyond him and many readers would agree that, with impeccable prose, crystal-clear thinking and considerable scholarship, in this volume he leaves a stimulating picture of the one-ness of life and the whole-ness of the universe.

The theme is developed in an evolutionary sequence to show how scientific knowledge and thought eventually widen out to find common ground with spiritual insight and belief. Yet as soon as the author reaches a point where a philosophy which is spiritually satisfying might emerge, he breaks off as if at the end of his tether.

The result is a book which, because of the almost poetic style in which the biological and astronomical material is presented, could be hard going for the general reader whose learning is now adjusted to the superlative illustrative diagrams, photographs and models used by the B.B.C. in its current research series on television. The student with some knowledge of biology will be left somewhat frustrated because the end leads to unsatisfying whimpers rather than a statement of sustaining revelations and beliefs.

This is a disappointment, because, without question, Berrill has out-of-the-ordinary gifts in presenting ideas through the written word. He should use them to finish this book.

Whether "You and the Universe" is improved by the extracts from Walt Whitman which launch each chapter will depend on taste. Certainly, the physical presentation will not be to everyone's liking. T. H. Hawkins

STRAIGHT-LINE DATA ANALYSIS

Analysis of Straight-Line Data

By Prof. Forman S. Acton. (Wiley Publication in Applied Statistics.) Pp. xiii+267. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 72*s*. net.

Prof. Acton demonstrates that a book the object of which is utilitarian can also be attractive to the reader, perhaps mainly because of the freshness of his style and his insistence on keeping close to real experimental problems. He is interested in answering the questions that experimenters need to ask, and early makes plain his attitude by stating: "If we waited for all the epsilons and deltas to be supplied before we used techniques that statistical common sense suggests, we would be technical paupers". His second chapter is probably the best systematic account yet available of the classical problem of simple regression, with its many ramifications in respect of errors and limits for different estimates; it should be read by all who imagine that they have nothing more to learn about these techniques.

In another major chapter, the frequently evaded topic of regression with both variates subject to error is discussed, and the similarities and differences between various practical situations are considered. The methods proposed owe much to Tukey, but Acton's own contribution is evident. Acton's presentation is distinctive among statistical texts for the blunt common sense of his recognition that the duty of the practising statistician is not simply to construct models, to test hypotheses, or to make decisions in accordance with abstract principles; he must interpret numerical data in whatever manner may be most appropriate to their source and their intended

use, recognizing the imperfections of these data but seldom admitting total defeat in his efforts at rational analysis. The writing is interspersed with remarks of refreshing directness and practicality: ". . . if our purpose is to analyse data realistically, we must face the anomalous situations which all too frequently occur rather than pretend that they do not exist. If the information is not precise, it is usually necessary to make some subjective judgments, and the best place to make them is where they have the least influence on the information extracted. If the assumptions turn out to be wildly different from the physical facts, the conclusions will be bad too, but the fault will be with the person who made the assumptions—not with the method of analysis".

Chapters on analysis of variance and on orthogonal polynomials are more conventional in pattern, though still containing ideas that too many authors neglect. The account of multiple comparison procedures is much condensed; some may wish that the author had brought his admirable critical sense to bear on this complex of methods, instead of simply accepting one, even though that one is possibly among the most useful. Later chapters attempt little more than to direct attention to aspects of regression on which further research is needed. Although Prof. Acton disclaims all intention of writing a text for class use, neither students nor their teachers could fail to gain from his book; both the novelty of its content and a style of writing that is vivid, unafraid of the telling metaphor or colloquialism, yet never obscure or verbose, should commend it both for its own sake and as an example.

D. J. FINNEY

THE PARANORMAL: A FRENCH VIEW

Treatise on Parapsychology

Essay on the Scientific Interpretation of the Human Phenomena known as 'Supernatural'. By René Sudre. Translated by C. E. Green. Pp. 412. (London: George Allen and Unwin, Ltd., 1960.) 35*s*. net.

THIS book is an attempt to provide the general reader with a survey of the whole field of psychical research from early times until the present day. It was first published in Paris in 1956, and its plan was clearly to allow other than English-speaking people to know something of what has been done in this field both in Great Britain and the United States, where the general attitude towards parapsychology is not the same as in France, Italy and other countries on the European continent.

M. Sudre is well equipped for the task he has set himself, for he has long been one of the most distinguished exponents of that point of view common in France early in this century but now being superseded. Closely associated for many years with Prof. Richet, Dr. Geley and others connected with the Institut Métapsychique in Paris, he has seen much and his attitude is typical of this group of French inquirers, being keenly critical of any theories savouring of spiritism, while at the same time somewhat credulous as to the reality of the phenomena to be interpreted.

After a brief historical survey the author proceeds to a discussion of the phenomena, linking them with sudden changes in what he calls the 'psychological personality', an alteration he terms 'prosopopesis'. He then passes to a consideration of telepathy, clairvoyance ('metagnomy') and the relation of a supposed psychic fluid to mesmerism, radiations and telergy. From consideration of this supposed action at a distance he then goes on to discuss 'teleplasty', or the objectivization of forms, and concludes his study by dealing with spontaneous cases, haunts, mysterious behaviour in animals and phenomena claimed by spiritists to be striking indications of survival after death.

M. Sudre's own opinions are anchored to his faith in the reality of the so-called physical phenomena. He believes in materialization, even going so far as to credit the partial dematerialization of mediums' bodies in séances: he believes in psychic photography and has many good things to say about such dubious mediums as Guzik, Kluski, Florence Cook, Reese, Kahn and even Kraus, although he does not give Kraus's name nor let the reader know that this person confessed to his frauds in an unpublished memoir. He even maintains that the phenomena at Borley Rectory were 'incontestably genuine' and this in spite of incontrovertible evidence to the contrary.

Since the author is convinced that certain human beings are endowed with these astonishing faculties, he finds the spiritistic explanation of little value and the evidence for survival, so painfully collected by the British and the Americans, he brushes aside as simply examples of 'perceptive metagnomy' and 'collective psychism', while at the same time he defends the theory that the so-called telepathic apparitions are objective and that the hallucinatory nature of these experiences cannot be maintained.

The book is well produced and translated, although it lacks an index of subjects, and some of the mistakes and misprints in the French edition (for example 'Mac-Aba' for 'MacNab') have been carried over into the English version, where more care in the standardization of references would have improved the book.

E. J. DINGWALL

A CENTURY OF NAVAL ARCHITECTURE

The Institution of Naval Architects, 1860–1960

An Historical Survey of the Institution's Transactions and Activities over 100 Years. By K. C. Barnaby. Pp. 645+11 plates. (London: The Royal Institution of Naval Architects, 1960. Published in association with George Allen and Unwin, Ltd.). 105*s*. net.

IN 1791 a laudable attempt was made to found a 'Society for the Improvement of Naval Architecture', but the venture was premature and therefore short-lived. By 1860, however, sail and steam were in competition, iron was challenging timber as a shipbuilding material, the mercantile marine was expanding rapidly and an era of swift technical advancement had begun. In these circumstances, the Institution of Naval Architects was brought into being by a small group of founder-members. It has been stated that the history of the Institution is the history of naval architecture, and the Institution, now 100 years old, has been honoured by its new title of the 'Royal Institution of Naval Architects' and has celebrated its centenary by meetings in London and by the production of this excellent and fascinating volume.

The preparation of "The Institution of Naval Architects—an Historical Survey" was entrusted to Mr. K. C. Barnaby, himself a naval architect of high repute, and he has accomplished his task with extraordinary success. He writes with lucidity, perspicacity and with the saving grace of humour. His method is to review each volume of the Institution's *Transactions*, reminding the reader of the existing state of knowledge and summarizing each paper with admirable brevity. Such a course might well be hazardous in less-skilful hands, but Mr. Barnaby is a master of his subject and is never guilty of airing either hindsight or superior knowledge. He can be forthright without being rude, and he can be complimentary without being condescending. Occasionally he is devastating, as when he describes one early paper, by a gallant admiral pontificating on warship design, as "a farrago of nonsense".

A perusal of these pages gives a clear and connected account of the advances in naval architecture and marine engineering since 1860. One reflects ruefully that a final solution is rare in applied science, for the problems of resistance, strength, stability, rolling and steering discussed in the earliest volumes are still, although in modified forms, the subjects of continuing investigations. One point worthy of note is that in discussion our forefathers were frank to the point of rudeness. Our present-day discussions of technical papers are colourless and stilted by comparison.

A centenary is perhaps as suitable an occasion for taking stock as any other. The Institution has tried to improve the status and the training of naval architects and has always been active in furthering efforts to improve the design, construction and safety of ships. But merchant ships, although they may well continue to provide the cheapest form of transport, are now subject to forms of competition undreamt of by the founders of the Institution. With warships the changes are no less marked, as, for example, the aircraft carrier supplants the battleship.

Research in naval architecture has, until recent times, been left to private enterprise and not heavily supported by government bodies or trade associations. The volume records a hundred years of technical advance and the next centenary will, one hopes, see accelerated progress in technical developments, if Great Britain is to retain its position of eminence in shipbuilding.

J. F. C. Conn

GROWING UP

Growing up in Newcastle upon Tyne

A Continuing Study of Health and Illness in Young Children within their Families. By F. J. W. Miller, S. D. M. Court, W. S. Walton and E. G. Knox. Pp. xxi + 369 + 9 plates. (London: Oxford University Press, 1960. Published for the Nuffield Foundation.) 25*s*. net.

THIS book is the second volume of an inquiry into the pattern and extent of illness during childhood in Newcastle upon Tyne. The first volume ("A Thousand Families in Newcastle-on-Tyne"), deals with the first year of life. The present volume is concerned with the age group of 1–5 years.

The investigation is continuing until 1962, when the children will be fifteen, and a third volume will cover the school years.

The study is based on observations during visits to the homes, by health visitors and doctors, on all infants born in Newcastle upon Tyne during May 1–June 30, 1947. The original 1,142 children have now shrunk by removals, withdrawals and deaths to 847.

The work, inspired by the late Sir James Spence, is an attempt to discover the occurrence and natural history of illness as they occur in families and to find out how the pattern and outcome of disease are influenced by the child's environment. Our knowledge of child ailments has hitherto been based on vital statistics, hospital attendances and the records of general practitioners. It shows how incomplete such knowledge can be, for in nearly half the illnesses the doctor was not called in.

The book follows the same pattern as the earlier one. A section is devoted to the environment of the child, under the headings: housing, family, and medical care. The housing, as one would expect in an industrialized city, left much to be desired, and many houses and flats were in a dilapidated condition and many families live in overcrowded conditions. About one quarter of the mothers were employed in whole- or part-time work.

After a preliminary discussion of the pattern of the illness in the first five years of life the authors go on to describe in detail the diseases group by group. It is shown that infective illness still causes 82 per cent of all morbidity in the first five years. Respiratory diseases ranging from heavy colds to pneumonias form nearly two-thirds of all infective illnesses. Fortunately, fatal illness is uncommon after the first year of life. The incidence of bronchitis was ten times higher in the families of labourers and unskilled workers than in professional families.

Tuberculous infection has steadily diminished in the period under review. In 1947, 85 deaths occurred in children under 15 years. By 1954 the total had fallen to four. As judged by tuberculin jelly tests, 7 per cent of the children had become infected by 5 years of age. This is a striking change as compared with the proportion of positive reactors twenty years ago.

One section of the book is devoted to conditions which are considered to be associated with the social environment. Alimentary infections occurred most frequently in families where there was deficient care of the child, or where the family was living in a small house with low rents and especially in tenamented and mouse-infected property in the older parts of the city.

Accidents, which are now one of the principal causes of death in childhood, comprise the other large group associated with the environment. Many of the home accidents such as burns, scalds and the swallowing of poisons are preventable. Accidents were found to be more prevalent in families where the quality of the mother's care was unsatisfactory.

In the final chapter the authors conclude that the health of the children and the outcome of diseases are closely related to family environment.

The statistical data are presented in a series of useful appendixes.

The book is a valuable addition to the knowledge of the pattern of childhood diseases in a community and of socio-economic factors which influence them. It should prove valuable to doctors working in family practice, preventive medicine and hospitals, as well as to health visitors and others who are responsible for the welfare of children.

G. H. Newns

Check-List of Birds of the World

Vol. 9. Edited by Ernst Mayr and James C. Greenway, Jr. (A Continuation of the Work of James L. Peters.) Pp. xii+506. (Cambridge, Mass.: Museum of Comparative Zoology; Copenhagen: Zoological Museum, 1960.) 7.50 dollars.

THIS is the basic modern work in systematic ornithology and was planned for fifteen volumes. Of these, Volumes 1–7 appeared in the period 1931–1951 and covered all the non-passerine birds and a few families of passerines. The death of Peters in 1952, with only a little more material ready in manuscript, made new arrangements necessary for completion. The editors appointed by the Museum of Comparative Zoology at Harvard are E. Mayr and J. C. Greenway, jun., and they have proceeded on the plan of apportioning the groups among selected specialists in America and Europe. This should speed up the issue of the remaining volumes, which will appear when ready and not in numerical sequence.

Volume 9 is thus the first to appear under the new arrangements. It covers a dozen passerine families of varying distribution—some cosmopolitan (for example, swallows), some purely Old World (bulbuls, etc.), some purely New World (for example, mocking-birds), and some very restricted (such as the vangas, peculiar to Madagascar). Each familial section has its own author, and other systematists who have read the manuscript in a consultative capacity are named in addition. The information given consists of the scientific names (with references) of each species and each sub-species thereof, and the distribution of each form.

The resumption of publication of this important work is most welcome, and on the new co-operative basis of authorship one may hope for early completion. One may then look forward to revised editions of some of the earlier volumes which are out of print as well as in parts out of date.

LANDSBOROUGH THOMSON

Institut National des Sciences et Techniques Nucléaires

Symposium de Métallurgie Spéciale organisé à Saclay les 27 et 28 Juin 1957 par le Département de Métallurgie et de Chimie Appliquée. Pp. iv+128. (Gif-sur-Yvette (S.-et-O.): Centre d'Études Nucléaires de Saclay; Paris: Presses Universitaires de France, 1958.) n.p.

AS the title suggests, this symposium concerned particular problems in nuclear metallurgy. Certain of the papers are transcriptions of previous published work. Naturally enough, the majority originate in France, but there are four outside contributions, from Holland, Sweden and Great Britain.

The main topic of the symposium is occupied with allotropic transformations, recrystallization and textures which result.

The transformations in uranium and zirconium and their various alloys are discussed from several aspects. One paper makes a comparison between uranium and iron.

The work on recrystallization and polygonization is treated from a variety of angles, and examples are illustrated from magnesium, aluminium, zirconium, cobalt and titanium, or alloys based on these metals.

As usual, some beautiful micrographs are reproduced, particularly those by Prof. P. Lacombe on polygonization in uranium, and the examination of alpha structures in uranium by Mme. Lehmann and H. Aubert. There is an interesting report on mechanical properties of magnesium-zirconium alloys which is relevant to British work soon to be reported by the Institute of Metals.

The discussion is included at the end of each paper, and the proceedings commence and terminate with the speeches of welcome and conclusion presented at the time.

C. R. TOTTLE

Sonderausschuss Radioaktivität

Bundesrepublik Deutschland, Zweiter Bericht, März 1959. Pp. 117. (Stuttgart: Georg Thieme Verlag, 1959.) 12.60 D.M.

AN impressive organization for measuring the contamination by radioactive materials has been set up in West Germany. The reported data for 1958 show a wealth of measurements of the concentration in the air near the surface, in water from different sources, in the soil, in plants, animals and bones of humans. Comparison of the data for 1958 with those of previous years shows no significant increase. An attempt to predict the increase in fall-out if testing of nuclear weapons is either discontinued or if it proceeds at the rate of the year under review indicates that substantial increases are to be expected. A survey of the results of the German film protection service shows that nearly 10 per cent of persons engaged in work connected with ionizing radiation receive doses of more than 0·4 r. per month. In future reports an estimate of the amounts of radiation received by patients in hospitals would complete an otherwise admirable survey. The data are set out in great detail in a large number of well-designed tables.

S. R. PELC

Linear and Stereoregular Addition Polymers

Polymerization with Controlled Propagation. By Norman G. Gaylord and Herman F. Mark. (Polymer Reviews, Vol. 2.) Pp. x+571. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 135*s*.

THE recent discovery of methods of synthesis of sterically regulated polymers is not only of fundamental scientific interest but also has opened up possibilities for far-reaching commercial application. Since Zeigler's spectacular discovery of the catalysts for the low-pressure polymerization of ethylene, and Natta's brilliant syntheses of stereoregular hydrocarbon polymers, an immense amount of research has been carried out during the past six years in scientific and industrial laboratories in Europe, the United States and Asia. This book summarizes systematically publications up to February, 1959, and also correlates the various characteristic features of the new processes. With the avalanche of new work being published it was a very noble task for the authors to attempt such a review. Much of the newer work is contained in an enormous number of patents, and since these still remain the most abundant source of information the chapter summarizing some 500 patent examples is one of the most valuable in the book.

While much more remains to be discovered about the mechanism of Zeigler catalysis and the nature of stereospecific polymerization, this book is the best source of information available. The authors have done a great service to polymer chemists in presenting a comprehensive and authoritative source of information on this new branch of polymer science.

C. E. H. BAWN

SCIENCE AND SOCIAL ORGANIZATION*

By Sir CHARLES GOODEVE, F.R.S.

THE scientific method has been as successful in helping in the operations of industry and civil government as it has in the military field; and there is also a growing amount of interest in a field which may be called 'social organization'. In this field, which is primarily a responsibility of government, the needs and the opportunities are great.

Scientists are repeatedly challenged by the accusation that they have been responsible for altering the lives of people and increasing their power to destroy one another, and yet have left most of the social problems so produced to others to solve. The advances of civilization arising from progress in science and technology have increased the extent of the interactions between what one person does and what another does or can do. These interactions require control, require social organization; but our knowledge of social interactions, and consequently our social organization, both lag behind.

Despite the encouragement of bodies such as the British and the American Associations for the Advancement of Science, scientists generally are, for a variety of reasons, reluctant to respond to this challenge. The objects and rules of social organization are substantially linked to moral issues, and science would not presume to replace faith or other human sources of principles in deciding these issues. Individual scientists, while confident that they can see moral issues as clearly as anyone, are often frightened of appearing unsophisticated or naïve if they intrude into the deep field of philosophy. They might even fear that they would have to relax the discipline of their scientific method; the controlled experiment, so fundamental to the scientific method, can rarely be relied upon in this field.

Similar fears were present when scientists began to enter the field of operations. However, confidence has grown through success, not only in solving particular problems, but also often simply by helping management to clarify their objectives and to define their terms (in the light of the objectives). Also scientists have taught management not just to measure but to subject their measurements, both in the taking and in the interpretation, to the rigorous methods developed by science. Operational research workers therefore have less excuse than other scientists for avoiding the study of social problems. They have not avoided them altogether, but they could do more.

The social sciences have made important advances in recent years, but these have been mostly of a qualitative nature. However, it is rapidly becoming possible to determine fairly accurately what people think and want and do. The science of 'attitude and behaviour surveys' has reached a stage such that governments now have a powerful tool to help them in their job of social organization. (By comparison, the referendum or town poll is very inaccurate and will become obsolete as soon as people learn this.)

Almost every operational research study has the difficult initial task of finding and stating the objective or the objectives; the solution of this is often in itself of great value to management. What is the objective of social policy, of social organization? The answer is, of course, more than just to control the interactions between people, more than just to raise the standard of living. Social policy has been a subject of infinite discussion since civilization began. Jeremy Bentham, the great English philosopher, was one of the first to attempt a precise definition with his proposed social policy: "what serves the greatest happiness of the greatest number".

It should help to clarify the objective if we could define some terms in a manner in which they can be measured and, with considerable hesitation, such an attempt is made here. People have wants or desires known to themselves which can be defined as the basis of motivation; their decisions will be generally in the direction of satisfying these wants. The extent to which material wants are satisfied is, of course, the 'standard of living', but this quantity is measurable only in respect of people living near the subsistence-level, and then only in a rather arbitrary way. For an increasing number of more affluent people, a much more comprehensive meaning of the word 'wants' is required—one to include those arising from psychological, spiritual and any other human source. It must also include a promise for the future and a reasonable insurance against sorrows and fears. Sometimes the expression 'standard of life' is used to indicate the extent to which all types of wants are satisfied. These comprehensive wants are, of course, impossible to measure directly, but their total is the basis of one important type of human action—migration.

Let us consider first two clearly specified groups of people, between which there is complete freedom to migrate. These groups may be specified geographically or by profession or in other ways. If there is a net migration towards, say, the second group, then the conditions under which that group lives, including its social organization, has a greater attraction, a greater drawing power than has the first. Let us associate with each group a quantity to represent the attraction and designate this quantity by the Greek word 'eudemony' (eudæ-mony).

To a scientist, quantities or properties are either 'intensive', such as temperature and pressure, or 'extensive', such as volume or length (the total being the sum of the parts). Eudemony, as here used, is

* Closing address at the Second International Conference on Operational Research, Aix-en-Provence, September 5–9.

clearly an intensive property, and furthermore it has all the characteristics of a potential, a sub-group of intensive properties. This means that it should be measurable in the same manner as other potentials, that is, by the spontaneous movement of the associated extensive quantity. Just as the comparative temperature of two bodies is determined by the direction of movement of heat, when restrictions or influences on its flow are absent, so the comparative eudemony of two groups of people can be determined by the direction of migration; this will tend to be from the region of lower eudemony to the one of higher.

Most actual migrations are not altogether free, and in addition are influenced by lack of knowledge or are biased by inertia or physical obstacles such as cost. For accuracy, one should carry out a controlled test in which representative samples of each group were exchanged and later the return migration studied. Where this is impracticable, perhaps the simulation techniques of operational research could be used. At all events, the influences due to ignorance or the special obstacles which cause actual migration to deviate from that of free conditions can usually be identified and allowed for.

These restrictions and influences should not weaken our confidence in the relationship between eudemony and migration; the impossibility of carrying out the frictionless Carnot cycle does not alter our confidence in defining and measuring temperature. Indeed, this parallel situation may encourage us to go further and to define the difference in the eudemony of two regions quantitatively as the influence or bias that would deliberately have to be put in to equalize the two return migrations in a controlled test. This influence could be put in by, for example, giving a monetary compensation to the sample that would go to the region of lower eudemony.

Essentially, what we have done is to define a property, the 'eudemony', of a group of people in a social system in terms of a measurable quantity, net migration. This concept of eudemony will require further analysis, but it will be generally agreed that it is related to the satisfaction or fulfilment of wants. Indeed, one can get a somewhat satisfactory physical picture of eudemony by considering it as the ratio of the satisfied to the unsatisfied wants. The acceptance of this latter picture is, however, not essential to the main conclusion, namely, that it is possible to measure the size of this property, because it is a potential, even though its components cannot be measured.

By the choice of the word 'eudemony' we are touching on the field of philosophy: Aristotle used this word to mean happiness through the satisfaction of all types of wants, with special emphasis on the non-material wants. However, it is to be emphasized that we are concerned here only with studying human behaviour and not with moral issues, not with whether the wants people feel are the right ones or not.

This hypothesis can be tested immediately against one's own intuitive ideas arising from the consideration of particular cases. Some cases will fit, some may not. Those scientists who have been brought up in the approach of thermodynamics and kinetics, of forces, equilibria and rates of change, may be more readily able to accept this than others. Most, however, will agree that the argument underlines the importance of freedom to migrate if one is ever to achieve an objective meaning to 'standard of life' or its associated quantity, eudemony.

In attempting to pull out a basic hypothesis from such a complex thing as life, one can scarcely expect to avoid some limitations or qualifications. A full analysis of these cannot be made here; but some important ones should be dealt with. I have defined eudemony as a property of a 'clearly specified group of people', but obviously it is necessary that there be a reasonable degree of similarity between the composition of the groups; if not, migration would need to be analysed in terms of sub-groups. We could not easily compare the eudemony of a group of Jamaicans in Kingston with a group of Englishmen in Birmingham, but we could with another group of Jamaicans in Birmingham. It would become practically meaningless to try to compare the eudemony of two individuals; but of course, it is part of the hypothesis that any one individual in a group can examine the eudemony of his present circumstances in relation to that of any other possible set of circumstances.

So far, the definition has been related to groups existing at one period of time, so that two-way migration is possible. However, we have already at hand a reasonable way of overcoming this limitation. For example, should a government wish to know whether a proposed change in the social organization will increase or decrease the eudemony of a particular group, then the attitude and behaviour survey techniques referred to above can provide a reliable answer in most cases, because these techniques can predict the effect of the change on migration.

An increase in eudemony could by itself be used as a basis for social policy; but, if used alone, progress would be very slow. In history it is the 'reformer', the man with vision for the future of mankind, who is the initiator of most social progress. However, each man of vision has strong, highly individual and often conflicting views as to what people should want, as to what should constitute a high standard of life. The attitude of the group, while objective, suffers from relative conservatism and ignorance.

Social progress requires the existence of the reformer, but if he is to succeed he must do two things: get the support of the knowledge of the specialists responsible for studying particular problems, and get his ideas of wants accepted by the people of the group. This means that he should continuously measure his ideas for any change in social policy against the effects of such a change on migration. By thus narrowing the gap of controversy, social progress may be facilitated.

The above analysis of an objective of social policy has been chosen in the hope that, among scientists, interest may be stimulated in the field of social organization. The need for such interest is very great. Could we help by analysing the systems used in choosing our leaders, by analysing further the methods of decision-taking in groups of people? Could we measure the 'democratic' content of a particular system of government, perhaps by determining the extent to which considerations of eudemony influence the policy of that government? If so, we might bring the word 'democratic' out of the realms of emotional politics into clearer focus. These are bold targets, but boldness and courage are needed if we are to bring social organization up to the standard required to-day.

AEROBIOLOGY AND MEDICINE

THE pioneer of aerobiology in the service of medicine was C. H. Blackley, a medical practitioner living in Manchester and a sufferer from hayfever, whose book, published in 1873[1], was a model of scientific method and is now indeed a classic. Blackley's countrymen were ultimately converted to his view that hayfever could beyond doubt be produced by inhaling pollen, but it was in the United States that the need for botanical collaboration in solving the medical problems arising from the inhalation of plant spores was first realized: and by 1940 the Americans had established an undoubted lead in this field. The extent to which knowledge of the botanical aspects of allergy has been advanced in Britain since that date was illustrated in the symposium held by Section K (Botany) of the British Association meeting at Cardiff entitled "Botanical Aspects of Allergy".

Dr. D. A. Williams, physician to the Asthma and Allergy Research Unit at Cardiff, set the stage for subsequent speakers. He recalled that the word allergy, meaning a different or altered reaction, was first coined in 1906, and that the two allergic diseases in which pollen and fungus spores play an important part are hayfever and asthma. Hayfever affects some 0·5 per cent of the population. It is entirely an allergic disease, due to pollen, in the main to grass pollen, and some 30–40 per cent of grass-pollen hayfever patients also have pollen asthma. Tree pollen, in particular birch, ash, elm and in some districts, plane, can cause quite severe hayfever and asthma, but it accounts for only a small percentage of hayfever patients; and the pollen grains of herbs other than grasses appear to be relatively unimportant. Asthma affects some 1·0 per cent of the population, and frequent incapacity occurs in some 15 per cent of asthmatics: its causes are only partially understood. The main causes are infections (colds) in the upper air passages, psychological factors and extrinsic allergens (inhalants or organic dusts, and also, but less frequently, foods).

Recent advances in our knowledge of the ætiology of inhalant allergy are almost all linked up with research on plant spores. Thus the clinical investigation of certain types of fungus spore as allergens has followed the lines suggested by the census (centred on Cardiff and referred to here) of culturable moulds in the air over Great Britain: some 5 per cent of asthmatics have been found to have asthma caused by such spores; the most abundant single type, *Cladosporium*, is also (among fungus spores) the commonest cause of asthma, which in this instance is often severe and persistent in summer. Less common, but accepted causes of summer asthma, are *Botrytis* and *Alternaria*. Apart from these common constituents of the aerospora, *Cladosporium fulvum* has long been known to cause allergic symptoms in those who work in greenhouses; and *Aspergillus fumigatus* has recently been shown in London to cause, not infrequently, quite severe asthma. Many other fungal spores are capable of producing asthma, but their exact medical importance awaits investigation.

Mr. H. A. Hyde (National Museum of Wales, Cardiff; honorary director of botanical research at the Asthma and Allergy Research Unit) reviewed the results of aerobiological research in the interest of medicine. When the investigation of plant spores in the air over Great Britain was first contemplated in 1941, no exact information existed on the kinds of pollen (or other spores) occurring in the air, or even of their dates of liberation, still less their relative abundance. Systematic trapping by the so-called gravity slide method began at Cardiff (where it has continued without a break since January 1942) and has since been extended in most instances for a period of a year or more to 15 other stations from the Scillies to Aberdeen and situated in urban, rural, coastal, mountain and maritime situations.

The order in which the various types of pollen appear in significant numbers in the air of Great Britain varies little from year to year; though it may be telescoped or drawn out according to weather. The most abundant types on the average probably throughout the country are four kinds of tree (elm, ash, birch and oak), three kinds of 'weed' (non-gramineous herbaceous plants), namely, plantain, *Rumex* (sorrel and dock), and nettle, and above all grasses. Of these, grass pollen is the least variable in its period of prevalence: its concentration, as measured by the Hirst trap, is almost negligible (a few grains per cubic metre) until late May, after which it soars rapidly to mean 24 hr. values of 500/m.^{3} or more by or before mid-June, and then falls more or less rapidly (except locally in the neighbourhood of late-flowering grasses) to a low figure by August. On sunny days during the peak period the 'spot' count rises late every afternoon in central Cardiff to between 1,000 and 1,750 grains/m.^{3}; though in sunless weather it may scarcely rise above zero. The grass pollen 'season' is probably more or less equally severe over the whole of the lowlands of England and Wales, but less in the mountains and of course increasingly less as one goes out to sea. Strictly indoor air (with doors and windows tightly closed) even on a sunny day in the lowlands at the height of the season contains little pollen. The inhalation of grass pollen in quantity can largely be avoided by following simple rules based on the present knowledge of its variation according to time, place and weather.

Tree pollens vary in their abundance very widely from year to year, so reducing the probability of sensitization to them. Nettle pollen is on the average numerically more abundant than any other kind except that of grasses, and, like its near relative pellitory-of-the-wall in southern Europe, it may prove to be an important allergen.

Study of the fungus aerospora in Britain began with a (gravity slide) census of *Alternaria* spores at Cardiff 1942–43: they were found to be present in numbers which suggested that *Alternaria* allergy might well occur in the human population. Further observations (by means of culture plates) followed from 1947 onwards.

Examination of the complete fungus aerospora by means of the Hirst trap, from 1957 onwards, has confirmed the findings of Drs. Gregory and Hirst at Rothamsted on its composition and has shown that

on average the fungus spores are 60–70 times as numerous as pollen grains. But this figure does not indicate their relative importance as allergens: the volumes of the various types of grain or spore must also be taken into account. When this is done and the various kinds are arranged in order of bulk abundance, that is, the volume of the spore (in μ^3) per unit volume of air, it is found that present views on the importance of grass pollen (which comes at the top of the list) and *Cladosporium* spores (which come second) are confirmed, and several kinds of pollen and fungus spores, all of them known or strongly suspected to act as allergens in Great Britain, come fairly high. Ascospores and basidiospores (both as yet mainly undifferentiated) come respectively third and fourth. It may well be that the latter will prove, as Gregory and Hirst have suggested, to merit serious consideration as allergens.

Principles are emerging from the work on inhalant allergens. Some types of plant spore are inherently more likely to evoke symptoms than others: among flowering plants high allergenicity is confined to a small number of families; we cannot yet say how it is distributed among the fungi. Other things being equal, the most abundant types of spore are the most likely to be important as allergens. Some kinds of spore are present in the air in effective concentration year after year; these are much more likely to produce sensitization than those the concentrations of which become high at longer and less regular intervals. When the concentrations of different kinds of spore are being compared, numbers should be weighted for size.

Dr. Merfyn Richards (Beecham Laboratories, Ltd.) discussed the mould spore population of the air. He said that work, by means of culture plate techniques, on the mould spores present in the air has enabled a picture to be drawn of the relative quantitative importance of the various kinds, and of when and where they occur. Surprisingly, perhaps, but fortunately for the allergist and the allergic individual, there are relatively few genera of moulds of great numerical importance in the air. At Cardiff more than 80 per cent of the colonies grown from trapped spores are identifiable. Of these 95 per cent or more are assigned to only a dozen genera; during three years, 1951–53, *Cladosporium* alone made up nearly half, and with *Penicillium* and *Pullularia* nearly three-quarters of the identified catch.

Several of these moulds have a 'season' of higher incidence. *Cladosporium*, *Epicoccum*, *Alternaria* and *Botrytis* occur in much higher numbers in the summer months than at other times. *Penicillium*, on the other hand, seems to be present in the same sort of quantities the year round.

The same kinds of mould spores occur in quantity at seven other centres up and down Great Britain, but *Cladosporium* shows a much greater incidence in rural areas, while higher counts of *Penicillium* are associated with the big cities.

The same mould genera which are most important numerically in the air over Britain are also the most important elsewhere in Europe, North and South America and New Zealand. In warmer climates than Britain, *Alternaria* assumes greater importance, and in places, for example the central United States, vies with *Cladosporium* for predominance.

The spores produced and released from the moulds growing in damp houses, cellars, barns, haylofts, granaries and workshops may in these places predominate over spores coming in with the ordinary outdoor air: such local modification of the spore load may be significant from the point of view of allergy.

Dr. Elizabeth Hamilton (Wright-Fleming Institute) described her current research with the Hirst automatic volumetric spore trap, in which airborne particles are impacted on to the sticky surface of a slowly moving microscope slide. The number of spores counted under the microscope on a traverse of known area can be converted into an estimated number per cubic metre of air, and it is possible also to tell, to within an hour, the time of day when any particle was deposited.

The 'spore-season' in London stretches from mid-May to November. Individual spore types have their particular seasonal incidence and there is within the season a day-to-day fluctuation in the counts, depending mainly on meteorological factors: there are 'associations' of spores which are predominant in dry weather and others which are predominant in wet weather.

Besides the annual and seasonal variations many airborne spores also have a distinct pattern of diurnal periodicity. This is dependent on the individual spore-type and also on the occurrence of those conditions of humidity, temperature and local air turbulence required for the liberation and dispersion of the spores. It is therefore apparent that if spore trapping is not continuous, the time of day when samples are taken will bias the findings.

This information on the season, the abundance, the time of day and the type of weather favouring different spores is all likely to aid the clinician in his diagnosis of spore allergy.

A note of the daily count is given to the Allergy Clinics at St. Mary's Hospital and data sheets summarizing the counts are sent each week to doctors who are interested in allergy.

Mr. R. Harvey (University College, Cardiff) described his investigations into the ecology of the genus *Cladosporium*, at least six species of which are in the aerospora, their proportions ranging at Cardiff from 0·2 to 45 per cent of the total. Under identical conditions growth-rates of individual species vary significantly, and in each species the process of spore production is much more sensitive to adverse environmental conditions than is vegetative development. Conidiophore development at humidities less than 65 per cent is often abnormal, and few spores are produced. Temperatures above or below the optimum range of 15–20° C. restrict sporulation, and at extremes above 27° C. or below 10° C. lead to abnormal conidiophore development. The presence of water droplets in the air markedly accelerates spore liberation.

The 'peak development' of each of the various species is reached at the time of maximum sporulation. Following their release, the further development of the fungus continues to be limited because of the effect of environmental factors (especially humidity) on the spores during their dispersal.

More than 10 per cent of the spores are released in clusters of 30 or more spores, but during dispersion these break up to form smaller clusters and, eventually, single spores. Both large clusters and single spores are essentially dispersal *units*—each of which effectively produces only one fresh growth on deposition.

Airborne spores are able to colonize a wide variety of ubiquitous organic materials. During spore

germination and subsequent colonization the environment continues to exert a restrictive influence, especially through the competition of other components of the mixed microflora.

The capacity for spore production is so great in each life-cycle that even in the winter months they are always present in the air in appreciable quantities.

The symposium showed that the aerospora has come to be recognized as a factor, or rather a complex of factors, comparable with those of weather, in the human environment. Observation on these factors is becoming increasingly detailed and precise: it is vitally important to the study of allergy.

H. A. Hyde

[1] Blackley, C. H., "Experimental Researches on the Nature and Causes of Catarrhus Aestivus (Hayfever)" (1873).

POLYMER CHEMISTRY

HIGH polymers were the predominant theme of the proceedings of Section B (Chemistry) of the British Association's meeting in Cardiff. Addresses were given on the technical and commercial developments of new products and their applications, the topics selected being polythene, epoxide resins and silicones. A full session was devoted to a discussion of current work on polymer chemistry, and although it was possible to cover only a small part of their enormous and expanding subject, the four papers presented gave a fair perspective of some of the important problems now engaging polymer chemists.

The recent discovery and commercial development of stereospecific polymers was the obvious starting point, and in the opening address Dr. P. R. Thomas referred to the significant discoveries of Ziegler on the synthesis of linear highly crystalline polythene, and of Natta on the polymerization of propylene and other α-olefins to high molecular weight crystalline products. He then described the investigations carried out by the British Nylon Spinners on the synthesis of stereoregular addition polymers containing amide groups, and in particular the N_1N disubstituted acrylamides:

$$\left(\begin{matrix}R_1\\R_2\end{matrix}\right\rangle N - CO - CH = CH_2\Big)$$

Using hexane or toluene solutions of lithium ethyl as catalyst, highly crystalline polymers were formed in contrast to free-radical or electron-transfer initiators, such as peroxides or sodium naphthalene, which gave polymers of low tacticity. Significant differences between the physical properties, infra-red absorption spectra and rate of hydrolysis of the isotactic and atactic forms were reported.

When polyethylene is irradiated *in vacuo* with X-rays the main effects observed are the production of hydrogen, cross-linking of the polymer and the formation of unsaturation at points along the chain. The cross-linking results from the union of free-radical centres formed on different chains. Not all the radical centres produced in the irradiation process are used in this way. Some are trapped and are potential centres for further reactions. Dr. T. T. Jones described their use in the grafting of polystyrene chains on to the polyethylene backbone. He showed that the rigidity of the swollen gel, in which polymerization takes place, greatly influenced the grafting reaction. Kinetic measurements indicated that, due to the immobilization of free radicals, the termination coefficient of the styrene polymerization reaction was considerably reduced compared with reaction in free styrene. The observed changes in the dynamic mechanical damping properties of the grafted structure were attributed to the interference of the graft polymer and the intimately mixed polystyrene in the crystallization of the polyethylene.

In the third paper, Mr. J. L. B. Benton reviewed the modern aspects of polymer structure and its relation to properties. He discussed the factors which determine the configuration taken up by the long-chain molecules in the crystalline regions of a high polymer, and showed how these depend on forces within the molecule—which determine the minimum energy configuration of the isolated molecule—and the interaction between molecular chains. Since the configuration taken up is the one of lowest energy, the plane all-*trans* plane zig-zag corresponded to the minimum energy configuration in polyethylene. In polytetra-fluoro-ethylene, the van der Waals's diameter of 2·7 Å (cf. hydrogen 2·2 Å.) caused an overcrowding in the all-*trans* configuration, and this was relieved by twisting each successive carbon–carbon bond 20° away from the precise *trans* form and opening up the tetrahedral bond-angle to 110°. This puts the fluorine atoms 2·8 Å. apart and leads to a spiral chain with thirteen CF_2 groups for each repeated distance. For the same reason he showed that isotactic vinyl polymers $(CH_2—CHR)_n$ with the *R* groups in corresponding positions—either all left-hand or all right-hand—formed a helical structure. In syndiotactic polyvinyl chloride no overcrowding occurs and the polymer assumes the all-*trans* form.

The crystalline melting point of a polymer is closely related to the flexibility of the chain—the more flexible the chain the lower the melting point, or the higher the potential energy barrier for rotation the higher the melting point. Dr. Benton showed that the same properties have a determining influence on the mechanical properties of the polymer. The transition in an amorphoris polymer does not involve bodily movement of whole molecules past each other, but only deformation of chain segments and these are determined by bond rotations. Rubbery properties will thus disappear in some critical temperature range where the thermal energy available to the bonds becomes so low that the co-operative rate of passage of the rotational barriers is reduced to negligible dimensions. This explains the high increase in modulus in the region of the glass temperature.

In the final paper, Prof. A. G. Evans surveyed his recent work on the ionic polymerization of 1 : 1-diphenyl ethylene. This monomer polymerizes only to the linear dimer 1,1,3,3-tetra phenyl but-1-ene because of the presence of the bulky phenyl groups. The reaction was initiated by cationic catalysts of the Friedel–Crafts type, and reproducible kinetic data were obtained only by working under conditions of extreme purification. No dimerization occurred with stannic chloride as catalyst unless water or hydrogen chloride was present as co-catalyst. There was no optimum ratio stannic chloride : hydrogen chloride, but with water a maximum rate occurred at the ratio 1 stannic chloride : 2 water. Similarly, titanium

chloride requires hydrogen chloride as co-catalyst and this and the above reaction were interpreted in terms of the rate-controlling reaction :

$$M + HM^{+}(SnCl_5^{-}) \rightleftharpoons HD^{+}SnCl_5^{-}$$

where M is a monomer, D is a dimer and $HM^{+}(SnCl_5^{-})$ is a complex formed in the initiating step.

Prof. Evans said that although lithium butyl formed a complex with the monomer in benzene solution, no dimerization occurred and this he ascribed to steric influences. In the presence of $TiCl_4 + HCl$ the lithium butyl was, however, a powerful dimerization catalyst. The reaction was heterogeneous and occurred under conditions in which $TiCl_4 + HCl$ alone did not induce reaction. C. E. H. Bawn

CARBON-14 MEASUREMENTS OF KNOWN AGE SAMPLES

By ELIZABETH K. RALPH and ROBERT STUCKENRATH, JUN.

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THE reliability of the carbon-14 method of dating was admirably demonstrated initially by W. F. Libby[1] with a series of measurements of samples of known age. These afforded confirmation of the basic assumptions of the method with an accuracy of approximately 10 per cent. Now, eleven years later, greater precision can be achieved with the improved techniques, and measurements of samples of known age are being conducted by several laboratories. These measurements are important because, with counting accuracies of the order of 1 per cent, the basic factors involved in carbon-14 dating must also be tested with equal precision. The basic factors are subject to the following questions : (1) Has the cosmic ray intensity been constant as assumed ? (2) Has the equilibrium condition between atmospheric $^{14}CO_2$ and the reservoirs, primarily the oceans, been stable ? (3) Is the distribution of atmospheric $^{14}CO_2$ uniform throughout the world ? (4) Is the accepted half-life value (5568 ± 30 years) correct ? (5) Are the isotopic ratios of the atmospheric carbon unaltered in the process of carbon intake by plants ?

These questions cannot be answered individually by measurements of single or small groups of samples of known age ; but, when a sufficient number have been dated, the specific answers will become apparent. In the meantime, the contributions of the various laboratories furnish information about the over-all accuracy of the method.

Samples of known age which have been measured in the laboratory at the University of Pennsylvania from 1958 until May 1960 are described here and the carbon-14 determinations are illustrated in Fig. 1 and listed in Table 1. In Fig. 1 the known ages are plotted versus the percentage deviations of carbon-14 counting-rates. These deviations are the percentage departures of each sample (after correction of the counting-rate for the age of the sample) from the average counting-rate value of 39 measurements of oak samples ranging in age from 110 to 203 years before present[2]. A statistical analysis of the data from these oak measurements (see Satterthwaite and Ralph[3]) demonstrates that within this small range of years, the carbon-14 oak values did not differ significantly from those determined by tree-ring counts of the samples, and that the efficiency of the counter remained stable during the period in which these measurements were made.

Moreover, the average counting-rate value, corrected to 'zero age', is 95 per cent of the value of the oxalic acid standard (National Bureau of Standards No. 4990). This percentage value agrees with that determined by other laboratories, and with the value decided on at the Groningen Radiocarbon Conference[4] for interlaboratory standardization. With this basis of calibration, the measurements of samples of known age may be compared with those of other laboratories using the oxalic acid standard. The oak measurements demonstrate, in addition, that this 95 per cent value is in agreement, at least within 1 per cent in counting-rate, with true ages in the time span of A.D. 1849 to A.D. 1756 (the range covered by the oak samples). It is, therefore, the best available basis for calibration for use in carbon-14 dating until the complete time span of known ages has been measured.

In Fig. 1 there appear to be three possible deviations from the average oak value. The deviations occur at 272 (A.D. 1687), 3256 (1297 B.C.), and at 3884 (1925 B.C.) years before present. The first of these, at approximately A.D. 1700, is confirmed by known age measurements of several laboratories[5–7]. The second deviation (1297 B.C.) may be indicative of a similar fluctuation in that era, or in combination with *P*-11, of an upward trend. Carbon-14 measurements of tree-ring dated *Sequoia* sections by Hans E. Suess[8] lend support to the latter. The third occurs close to the 2000–4000 B.C. time-interval, where other nonconformities between carbon-14 dates and archæologically estimated chronologies, notably Egyptian, have been found. These older samples have not

Table 1. List of Percentage Deviations of Samples of Known Age from Oak Standards

Sample No.	Known age Years A.D. or B.C.	Years B.P.*	Percentage deviation from oak standards
P-263 (oxalic acid standard)			+ 4·99 ± 1·06
P-259	A.D. 1779 ± 5	180 ± 5	+ 0·591 ± 0·551
P-168	A.D. 1773 ± 15	186 ± 15	+ 0·040 ± 0·940
P-226	A.D. 1703 ± 3	256 ± 3	+ 1·039 ± 0·457
P-167	A.D. 1686 ± 16	273 ± 16	+ 2·654 ± 0·554
P-274	A.D. 907 ± 10	1052 ± 10	− 0·134 ± 1·216
P-283	A.D. 753 ± 28	1206 ± 28	− 0·591 ± 0·516
Tikal IV	A.D. 746 ± 5	1213 ± 5	0·00 ± 0·156
Tikal I	A.D. 704 ± 9	1255 ± 9	− 0·240 ± 0·215
P-268	A.D. 617 ± 7	1342 ± 7	+ 1·139 ± 0·538
P-272	A.D. 575 ± 10	1384 ± 10	− 0·501 ± 0·408
P-30	525 ± 25 B.C.	2484 ± 25	+ 0·688 ± 0·380
P-222	550 ± 25 B.C.	2509 ± 25	− 0·003 ± 0·445
P-134, *P*-275	714 ± 9 B.C.	2673 ± 9	+ 1·058 ± 0·342
P-227	1297 ± 7 B.C.	3256 ± 7	+ 2·234 ± 0·457
P-11	1925 ± 75 B.C.	3884 ± 75	+ 2·340 ± 0·246

Average counting-rate of 39 oak measurements = 32·143 ± 0·033 c./m.
* B.P., before present.

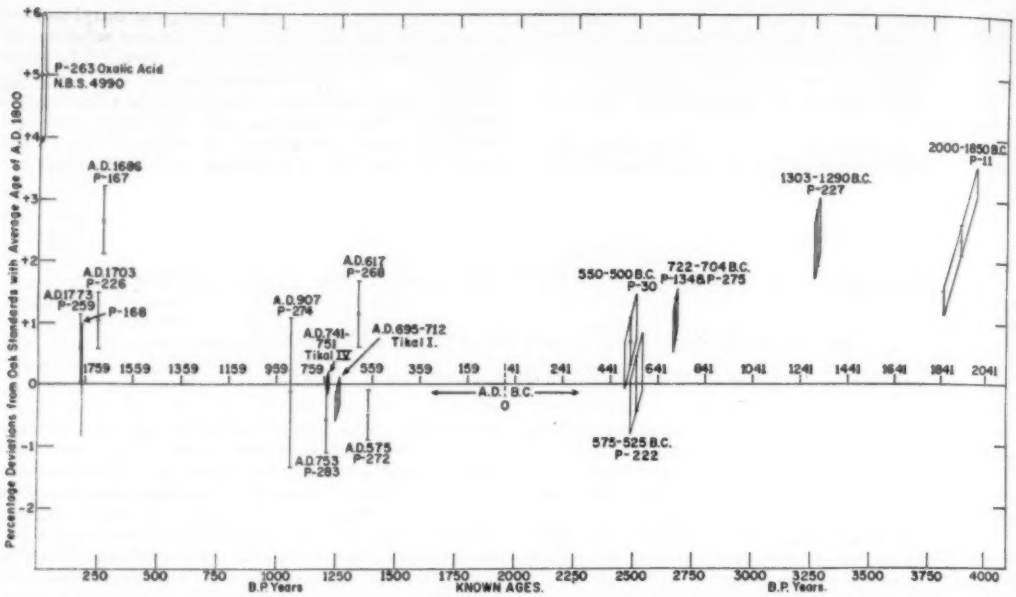

Fig. 1. Percentage deviations of samples of known age from oak standards. The 'zero age' counting-rate of 39 oak measurements is represented by the horizontal line through 0 per cent. Standard statistical deviations (one sigma) of the average of the carbon-14 known age determinations for each sample are represented by vertical lines drawn through the midpoints of the known age ranges. For tree-ring dated samples, the midpoints of the known age ranges are assumed to be the average ages of the portions selected for carbon-14 dating. The uncertainties in known ages of the archæologically dated samples are represented by parallelograms to allow for the possibility that the true age of the sample may lie at either extremity of the given range, thus presenting a greater uncertainty in the known date than if the true date were at the midpoint of the range

been included in this summary because of the greater uncertainties in the archæological dating.

If we accept these three fluctuations as significant, the nonconformities in terms of years are as follows :

P-167 (A.D. 1687) 211 ± 45 years too young
P-227 (1297 B.C.) 176 ± 53 years too young
P-11 (1925 B.C.) 186 ± 31 years too young.

It is obvious that these few measurements do not cover completely the time-interval of the past 4,000 years, nor do they answer the specific questions. However, they do indicate that the maximum error in carbon-14 dates due to methodological uncertainties could be of the order of approximately 200 years. In some time-intervals, A.D. 1849–1756, A.D. 900–600, and 500–700 B.C., this maximum error is very much smaller, and perhaps negligible (see Fig. 1). Further conclusions must await the completion of measurements covering the whole known age time span and more regions of the world.

Descriptions of Known Age Samples

A. Dendrochronologically Dated Samples

Oak Samples. *Quercus* sp., probably *alba*. Laboratory standard samples. Thirty-nine measurements of nine different oak samples from Round Top Hill (40° 20′ 30″ N., 74° 50′ 0″ W.), Mercer County, New Jersey, U.S.A., elevation 400 ft., which range in age from 110 to 203 years before present. Average age of the nine samples is A.D. 1800.

P-259. *Pseudotsuga taxifolia*. From 'Hitchcock Tree' from Santa Catalina Mountains (32° 25′ N., 110° 40′ W.), 25 miles north of Tucson, Arizona, U.S.A., elevation 6,500 ft., blown down in 1951. Rings marked A.D. 1774–1784 processed. Expected date : A.D. 1779 (180 before present). Two counting runs.

P-168. *Pseudotsuga taxifolia*[9]. From Mesa Verde (37° 12′ N., 108° 30′ W.), Colorado, U.S.A., elevation 6,900 ft., cut in May 1950. Laboratory of Tree-Ring Research No. *MVR* 3041-6*D*. Rings marked A.D. 1758–1788 processed. Expected date : A.D. 1773 (186 before present). One counting run.

P-226. *Pseudotsuga taxifolia*. From same section as *P*-259. Rings marked A.D. 1700–1706 processed. Expected date : A.D. 1703 (256 before present). Three counting runs.

P-167. *Pseudotsuga taxifolia*. From same section as *P*-168. Rings marked A.D. 1676–1702 processed. Expected date : A.D. 1686 (273 before present). One counting run.

P-274. Pine. From Chetro Ketl, Chaco Canyon (36° 05′ N., 107° 55′ W.), New Mexico, U.S.A. Laboratory of Tree-Ring Research No. *CK*-852. The pith year (start of growth) of this tree is A.D. 883. Rings marked A.D. 897–916 processed. Expected date : A.D. 907 (1052 before present). Two counting runs.

P-283. *Pseudotsuga taxifolia*. From Nine Mile Canyon (39° 48′ N., 110° 20′ W.), Utah, U.S.A., elevation 6,500 ft. Collected by John Gillin in 1939 (University of Utah, Museum of Anthropology No. 21754 ; 13–3)[10]. The pith year of this tree is A.D. 725. Rings marked A.D. 725–781 processed. Expected date : A.D. 753 (1206 before present). One counting run.

P-268. *Pseudotsuga taxifolia*. From Broken Flute Cave (36° 45′ N., 108° 50′ W.), 40 miles north of Chinle, Arizona. Sample from Room 6, north-east post, Laboratory of Tree-Ring Research No. *MLK*-127. Rings marked A.D. 610–624 processed. Expected

date: A.D. 617 (1342 before present). Two counting runs.

P-272. *Pseudotsuga taxifolia*. From same section as *P*-268. Rings marked A.D. 570–580 processed. Expected date: A.D. 575 (1384 before present). Three counting runs.

The dendrochronological analyses of samples *P*-259, *P*-226, *P*-274, *P*-283, *P*-268, and *P*-272 were made by the Laboratory of Tree-Ring Research, University of Arizona, Tucson, Arizona, and those of samples *P*-168 and *P*-167, by J. L. Giddings, Brown University, Providence, R.I. Sample *P*-283 was obtained from the University of Utah, Salt Lake City, Utah; the others, from the Laboratory of Tree-Ring Research. We wish to express our appreciation to T. L. Smiley (University of Arizona), to J. D. Jennings (University of Utah), and to J. L. Giddings (Brown University) for these important contributions to the known age dating project.

B. Archæologically Dated Samples

Samples obtained from the University Museum of Philadelphia.

Tikal IV and Tikal I. *Achras zapota*. Samples from vault and lintel beams from Temple IV (*P*-235, *P*-236, *P*-237, *P*-238, *P*-242, *P*-243, *P*-244, *P*-245, *P*-248, and *P*-249) and Temple I (*P*-230, *P*-232, *P*-234, *P*-247, and *P*-251), Tikal (17° 13′ 18″ N., 89° 38′ 30″ W.), Peten, Guatemala. For Temple IV, thirty-three counting runs of ten different beams and for Temple I, seventeen runs of six different beams were made. According to the "11–16" Maya-Christian correlation, the dates of the Temple IV beams are within the range of A.D. 741–751 (1218–1208 before present) and those of Temple I, A.D. 695–712 (1264–1247 before present). Reasons for acceptance of this correlation and details of samples selected are given by Satterthwaite and Ralph[3].

P-30, *P*-222, *P*-134 and *P*-275. Gordion Samples. Gordion (39° 45′ N., 31° 55′ E.), Turkey is the capital of a Phrygian Kingdom which fell before an invasion of Cimmerian barbarians early in the seventh century B.C. The town (the City Mound) was rebuilt in the time of the Persian Empire and continued to be occupied to about the third century B.C., but most of the numerous tomb mounds were undisturbed until excavations were begun in 1950 by the University Museum of Philadelphia under the direction of R. S. Young.

P-30. Tumulus *F*, Gordion. Charcoal from an undisturbed cremation-burial. Among the finds was jewellery of the Persian period (post-546 B.C. at Gordion) parallel to that from Tumulus *A*. Tumulus *A* was a similar cremation dated by the presence of a terracotta 'kore-unguentarium' with the same front- and back-moulds as those used in Samos in strata dated to the tyrant Polycrates (532–522 B.C.)[11]. Allowance of a short period for travel to Gordion, and for its worn condition, makes 550–500 B.C. (2509–2459 before present) a reasonable date for the Tumulus *A* cremation, and, therefore, for Tumulus *F*. Three counting runs.

P-222. Tumulus *H*, Gordion. Charcoal from Tumulus *H* cemetery, Burial *A*-161, an undisturbed grave of the Lydian period which contained a 'lydion' or ointment-jar painted in the 'marbled' technique. Such lydions have been found associated with the burnt fortification on the 'smaller mound' (*KH*) at Gordion. Estimated date: 575–525 B.C. (2534–2484 before present). Two counting runs.

P-134 and *P*-275. Tumulus *MM*, Gordion. The largest of these mounds (Tumulus *MM*) contained the 'Gordius' tomb. Young[12] has determined the date of completion of this tomb by parallels with Assyrian objects from the time of Sargon II, who reigned from 722 until 705 B.C. (2681–2664 before present). Samples *P*-134 (reported previously[13]) and *P*-275 were found in this tomb and are probably contemporaneous with its completion. *P*-134 consisted of fragments of organic matter, possibly food, from bowl No. 148, and *P*-275, of maple (*Acer pseudoplatinus*), part of a table-top, which is believed to have been made for the entombment. There was no necessity for re-use of wood, as the rolling hills on the plateau around Gordion are known to have been forested, on evidence of abundant deer bones found in habitation-levels. These two samples (*P*-134 and *P*-275) exhibited no significant differences in carbon-14 counting rates. One counting run of *P*-134 and three of *P*-275.

P-227. Seti I Beam. Wooden beam from Egypt with a cartouche containing the name of Seti I who reigned from 1303 until 1290 B.C.[14] (3262–3249 before present). The reign of Seti I has been firmly dated by its relationship to the recorded Sothic cycles. The collection date and original location of this sample in Egypt are not known. The beam is small, approximately 9 × 6 cm. in cross-section. The tree-ring patterns indicate that it was part of a small tree or branch. In other words, the portion used for dating was probably representative of the date of the cutting of the tree and of inscribing the cartouche unless it was an older re-used beam. Two counting runs.

P-11. Aha-nakht Sarcophagus. Wood, probably cedar, from the outer sarcophagus of Aha-nakht, El Bersheh (27° 45′ N., 30° 45′ E.), Egypt. Found in a tomb which was covered with earth. Aha-nakht lived sometime between 2000 and 1850 B.C. (3959 and 3809 before present), based on the early Kings' lists and archæological evidence[15]. As can be seen in Fig. 1, this sample is not so firmly dated as the others in this list. In addition, there may be a post-sample-growth error (not shown in Fig. 1), that is, the sample dated may be from the inner rings and, therefore, possibly 100 years older than the time of death of the tree. The portion for dating was taken from a beam approximately 45 cm. wide which had been squared and reduced in thickness to approximately 10 cm. Eight counting runs. (Preliminary carbon-14 dates for both *P*-227 and *P*-11 were reported previously[16].)

We wish to acknowledge with gratitude the financial support of the National Science Foundation for these measurements.

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OBITUARIES

Prof. N. E. Svedelius, For.Mem.R.S.

Prof. Nils Everhard Svedelius, the eminent Swedish botanist, died at Uppsala on August 2. He was born at Stockholm on August 5, 1873, of an old family noted for its scholarship and public service, which took its name from the small town of Sveden, in Dalecaria. Going to the University of Uppsala in 1895, he was later elected curator of the Stockholm nation. This student office gave him an early acquaintance with the business side of university affairs and led to his abiding interest in administration in which he played a prominent part at Uppsala.

Uppsala has always played a very prominent part in cryptogamic botany, for a long line of eminent botanists have made the different groups their special study. Svedelius, under the guidance of F. R. Kjellmann, who was noted for his researches on Arctic algae, took up the study of those of the Baltic, which provided the subject of his doctorate thesis in 1901. After studying at Munich that year, he journeyed to Ceylon, the East Indies and Java, 1902–3, where he gained a knowledge of tropical algae which ever afterwards stood him in good stead; a paper on the algae of the coral reefs of Ceylon, 1906, was one result of these travels, but their influence is seen in his discussion of the discontinuous geographical distribution of some tropical and subtropical marine algae, 1924. He was a prolific writer on algology, treating practically every aspect of this wide field, but his most important contributions were on the anatomical structure and development, and on reduction divisions and alternation of generations in the Florideae. It may be said that Svedelius and his pupil J. H. Kylin, later of Lund, initiated the study of algal cytology at Uppsala.

In 1908, he found that, in the tetrasporangium of *Martensia*, the tetrad is formed by only one of the numerous cell nuclei. Working with *Delesseria sanguinea* in 1912–14 he confirmed Yamanouchi's discovery of alternation of generations with changes of nuclear phase in the red algae.

In 1915 he discovered that in *Scianaia furcellata*, which lacks tetraspores, meiosis sets in immediately after the fertilization of the female nucleus which had invaded an auxiliary cell; one of the four nuclei gives rise to the gonimoblast which has haploid nuclei. Then, in 1933, he showed that meiosis begins immediately after fertilization in *Asparagopsis* and *Bonnemaisonia*. In monospore cultures, 1937, he proved that in *Lomentaria rosea*, where there are no sexual individuals, tetraspores are formed without meiosis, unlike *L. clavellata*, which is typically diplobiontic, having separate tetrasporous and sexual individuals. In 1942 he found that *Galaxaura*, closely related to *Scianaia*, has separate tetrasporous individuals. He finally reached the conclusion, therefore, that the sole criterion of a haplobiontic or diplobiontic development can no longer be regarded as of any great systematic importance.

Svedelius was soon regarded as among the foremost algological systematists; indeed, so early as 1911 he wrote the section on Bangiales in Engler and Prantl's "Pflanzenfamilien".

It would probably be true to say that Svedelius used his extraordinarily wide knowledge of algology to note problems which needed to be solved if theories based on insufficient facts were not to hold continued sway. By selecting these for the most part, though in no wise neglecting other opportunities which came to hand, he deservedly gained his great reputation.

In 1914 he succeeded H. O. Juel as professor of botany at Uppsala, and prælector of the University Garden. Juel had written a full account of Burser's herbarium and Svedelius saw it through the press. Burser, who died in 1639, left a *hortus siccus* of twenty-five volumes, the result of extensive continental journeys. This, one of the treasures of Uppsala Museum, had many vicissitudes before, surprisingly, reaching Uppsala—and then suffered the loss of two volumes in the great fire of 1702. It contains many specimens of C. Bauhin which enabled Linnæus to recognize his types. It is of fundamental importance in botanical nomenclature which, however, does not do away with its intrinsic historical value.

Svedelius was an authority on the lives and works of his great predecessors and, not unexpectedly, of Linnæus. The old University Botanic Garden, which Linnæus had reorganized and made famous, was left to become scientifically derelict after Gustav III had presented the gardens of the Royal Palace to the University on the urgent representation to him by C. P. Thunberg that the old garden was in a marshy district and otherwise unsuitable. Svedelius was one of the foremost of those who forced through a scheme in the early '20's for rearranging the Garden as it was in Linnæus's time and to ensure its future care.

Like most Swedish botanists, Svedelius did a good deal to popularize the subject in articles, and also wrote a popular book.

Prof. Svedelius represented Sweden at many botanical congresses and was also personally well known from his visits to foreign institutions. His quiet demeanour, with apt comments when such were in place, together with his evident enjoyment of the humorous gained him general affection.

He held many foreign distinctions. In Britain he was foreign member of the Linnean Society (1917), and the Royal Society (1944), and honorary member of the Botanical Society of Edinburgh (1938).

John Ramsbottom

Sir Arthur Fleming, C.B.E.

The death of Sir Arthur Fleming on September 14 will have saddened all who are concerned with the improvement of our national facilities for engineering education and training, and most of all those many thousands of men who were privileged to benefit from the schemes of apprenticeship which he pioneered within the Metropolitan-Vickers Electrical Co., Ltd. (now, Associated Electrical Industries (Manchester), Ltd.) more than fifty years ago.

He was born at Newport, Isle of Wight, in 1881, and was educated at the Portland House Academy there and at the Finsbury Technical College in London. After occupying positions with the London Electric Supply Corporation and a firm of instrument makers, he was selected by the British Westinghouse Co., later Metropolitan-Vickers, Manchester, as one of the 'holy forty', to undergo a course of training

with the Westinghouse Electric and Manufacturing Co. at its East Pittsburg works. On joining the Manchester company, he was engaged as a specialist in electrical insulation and soon became chief designer, and then superintendent and chief engineer, of the Transformer Department.

It was not long before Fleming introduced arrangements for the systematic training and further education of the young men in this Department, and from this beginning grew the Education Department of the Company, of which he became director. He used often to say that the most important raw material of industry was its young people, and he devoted himself to ensuring that his own young people, from the embryo craftsman to the university graduate, were recognized and treated as such. They came not only from schools and universities in Britain, but also from all over the world, for in the sphere of industrial training the names of Fleming and Metro-Vickers became international bywords; and there can scarcely be a country in which there are not several, indeed many, men who hold 'A. P. M.' in honour and who would welcome the opportunity to express their deep gratitude for his efforts on their behalf. His influence and inspiration in this sphere were not, of course, confined to his own Company; they penetrated widely within the electrical industry as a whole, and the benefits they have brought to the progress of this industry have been profound.

All this, however, was only part of his achievement. His far-sighted views on engineering education and training were matched by his realization of the need for research within industry, and especially for research which was not bounded by the problems of existing products. In parallel, therefore, with his establishment of schemes of apprentice training, he began to create a research department within the Company, to which he attracted a succession of men of outstanding ability and who responded to his inspiration by making many notable contributions in pure as well as applied science. A particular example of his remarkable foresight was his forceful contribution to the establishment of radio broadcasting in Britain. He retired from his directorship of research and education in Manchester in 1952.

Fleming's outside interests and activities were manifold. He was a member of the Council of the University of Manchester, of the Governing Body of the Imperial College of Science and Technology in London, of the Delegacy of the City and Guilds of London Institute, of the Ministry of Education Committee on the Training of Teachers and Youth Leaders, and of the War Cabinet Engineering Advisory Committee; chairman of the Electrical Engineering Committee of the Central Register of the Ministry of Labour, of the Athlone Fellowship Committee of the Board of Trade, and of the Federation of British Industries Overseas Scholarships Committee; and president of both Sections G (Engineering) and L (Education) of the British Association, and of the British Association for Commercial and Industrial Education. He also played an important part in the establishment of the Department of Scientific and Industrial Research and of the Electrical Research Association.

Within all these interests, the Institution of Electrical Engineers occupied a place of special importance; he became a member of its Council in 1932, was elected a vice-president in 1935 and president in 1938; and for his outstanding services to the profession was awarded the Faraday Medal in 1941 and elected to honorary membership of the Institution in 1952.

The Universities of Manchester and Liverpool conferred honorary doctorates upon him; he was made C.B.E. in 1920 for his contribution to submarine detection; and knighted in 1945 for his services to education.

Those who knew him well will remember him with admiration for his exceptional foresight, his unlimited enthusiasm and vitality, his unrestrained willingness to make his knowledge and experience widely available, and his devotion to the needs of the younger generation. Many more who did not know him have cause to be grateful for the benefits that have come from his life of public service. WILLIS JACKSON

NEWS and VIEWS

Chemical Technology at the Imperial College of Science and Technology, London: J. S. Rowlinson

THE chair of chemical technology in the Imperial College of Science and Technology was held for many years by the late Sir Alfred Egerton, but it was not filled after his retirement in 1952. It has recently been announced that Dr. J. S. Rowlinson, senior lecturer in the Department of Chemistry, University of Manchester, has now been appointed to the chair. Dr. Rowlinson had a distinguished career at Oxford, where he was Millard Scholar at Trinity College. He obtained first class Honours in chemistry in 1948 and the degree of D.Phil. in 1950. Leaving Oxford, he went as a Research Associate to the University of Wisconsin for a year, before going to the University of Manchester, where he was first an I.C.I. Fellow and afterwards lecturer, and more recently senior lecturer. Dr. Rowlinson received a Meldola Medal of the Royal Institute of Chemistry in 1954 and the Marlow Medal of the Faraday Society in 1957. Among his outside contacts it may be mentioned that he was formerly a member of the Thermodynamics Committee, National Engineering Laboratory, and he is at present a member of the Joint Sub-Committee of the National Physical Laboratory and the National Chemical Laboratory on Fundamental Properties of Pure Materials. He has carried out research on experimental and theoretical aspects of compressed gases, liquids and solutions, and he is the author of a book entitled "Liquids and Liquid Mixtures" published last year. Dr. Rowlinson goes to the Imperial College at a time when it is expanding rapidly.

Physiology at the Royal Free Hospital School of Medicine, London: Prof. C. B. B. Downman

DR. C. B. B. DOWNMAN has been recently appointed to the Sophia Jex-Blake chair of physiology at the Royal Free Hospital School of Medicine, London, in succession to the late Prof. Esther Killick. Dr. Downman was educated at the City of London School and St. Thomas's Hospital Medical School.

In 1937, after preclinical studies, he graduated B.Sc. (Lond.) with first-class honours in physiology and in 1953 he obtained his Ph.D. (Lond.). In 1938, a junior appointment in the Department of Physiology marked the beginning of his research association with the late B. A. McSwiney. In 1941, he was promoted to lecturer and later senior lecturer, until 1954, when he moved to the Royal Free Hospital as reader in physiology. Dr. Downman is well known internationally for his investigations in neurophysiology. His main work lies in the field of visceral afferent reflexology, early papers being concerned with vascular reflexes of skin and with the distribution of afferent fibres of the intestine; the spinal cord and cerebral distribution of splanchic afferent impulses has been mapped and the properties of the reflexes set up by such impulses has been analysed. More recent work has been concerned with the controls of these arcs in the brain stem. During the Second World War Downman was for a time a member of a team investigating oxygen poisoning at the National Institute for Medical Research under the leadership of Sir Lindor (then Dr. G. L.) Brown. In 1948 he went to Dunedin, New Zealand, for one year, where in collaboration with J. C. Eccles he studied spinal motoneurone physiology. In 1953 he went to the United States and together with C. N. Woolsey studied the interdependence of the subdivisions of the auditory cortex.

The British Biophysical Society

It is proposed to form a new society, to be known as the British Biophysical Society, the object of which will be to provide a common meeting ground for those interested in the functioning and structure of living organisms viewed from a physical point of view and in the application of physical and physico-chemical techniques to biological problems. The first meeting of the new society will be held at King's College, London, during December 19–20. It will consist in part of symposia, with invited speakers, on comparative work on muscular contraction and on the structure of ribonucleic acid, and in part of short contributed papers on the subjects of the symposia or on other subjects. Those interested in joining the Society or in attending (or contributing papers to) the meeting should apply to the honorary treasurer, Dr. P. M. B. Walker, Department of Zoology, West Mains Road, Edinburgh 9. All other correspondence should be addressed to the honorary secretary, Dr. J. C. Kendrew, Peterhouse, Cambridge.

Radioactive Contamination of Materials and Reagents

The Committee of the International Commission on Radiological Units which is concerned with Standards and Measurement of Radioactivity has appointed a sub-committee to report on problems arising from low-level radioactive contamination of raw materials used in various types of scientific work. Particular attention is being given to: contamination in shielding materials; contamination in the materials used in the construction of detectors and in the mounting of sources; contamination of reagent chemicals used in the separation for analysis of small quantities of radioactive material. The aims of the Sub-Committee are four-fold: to collect general information on the occurrence of contamination, in raw materials, for the information of possible users; to trace the origin of the contamination found in particular materials; to consider whether tests might be made at certain points in a manufacturing process or in distribution, to ensure that the level of any possible contamination was less than a defined amount; to consider special operations in tracer work or in the preparation and use of standards of radioactivity, where unsuspected radioactive contamination of reagent could lead to significant errors in measurements. The chairman of the Sub-Committee is Dr. N. G. Trott (Institute of Cancer Research), and the members are as follows: Mr. C. O. Peabody (Atomic Energy Research Establishment); Dr. B. Grinberg (Centre d'Etudes Nucléaire de Saclay); Dr. W. W. Meinke (University of Michigan); Dr. R. Brown (Atomic Energy of Canada, Limited, Chalk River). Dr. J. Rundo of the Health Physics Division, Atomic Energy Research Establishment, Harwell, is to act as consultant.

Russian Intelligentsia

The summer issue of *Daedalus* deals with the condition and prospects of a body of intellectuals known in Russia, pre-Revolutionary and Soviet, as the 'intelligentsia'. In Russia the question of the social function and historic mission of the intellectuals has a particular urgency, first because the early and rapid Westernization of the country produced an extraordinarily large, virile and self-conscious body of intellectuals, and secondly, because there modernization has been carried out with greater intensity and single-mindedness than anywhere else in the world.

What is the 'Russian intelligentsia', or an 'intellectual' or 'intelligent' anywhere? As the passage quoted by Leopold Labedz at the beginning of his essay suggests, these terms can mean all sorts of things to all sorts of people. Some use the term intelligentsia to refer to anyone engaged in non-physical labour, whether he is a lyric poet or a veterinarian (such, for example, is the official Soviet definition); others apply it to a person with a liberal education regardless of the nature of his employment; yet others confine it to persons critically disposed to the existing economic and political order, and ready to sacrifice themselves in order to change it fundamentally in accord with some higher (but secular) ideal. Ultimately, the criterion turns out to be a subjective one, and, to define the term 'intelligentsia' with any degree of accuracy, it would be necessary to have free access to all the groups which could possibly come within the meaning of the term. But this is not possible. The lack of direct access to the Russian intelligentsia of to-day posed difficulties for the writers in *Daedalus*. Rather than seek a comprehensive treatment of the intelligentsia of Russia, it seemed preferable to the authors to concentrate on several crucial aspects of the problem. To begin with, there is the question of the character of the pre-Revolutionary intelligentsia; in particular, its attitude toward civic responsibility. The first of these topics is treated by Martin Malia, the second, from different standpoints, by Leonard Schapiro and Boris Elkin.

"Science, the Endless Frontier"

As part of the observance of its tenth anniversary, the National Science Foundation has re-issued the report, "Science, the Endless Frontier", which Dr. Vannevar Bush, director of the Office of Scientific Research and Development, presented during July 1945 to the President of the United States on a pro-

gramme for post-war scientific research. The report is reprinted as a handsome brochure together with the reports of the four specialist committees—the Medical Advisory Committee, the Committee on Science and the Public Welfare, the Committee on Discovery and Development of Scientific Talent, and the Committee on Publication of Scientific Information. Dr. Bush himself contributes a foreword, and the whole is now provided with an index, which enhances its value to all concerned with the relations between science and government and education. An admirable introduction by Dr. A. T. Waterman, director of the National Science Foundation, summarizes the extent to which the recommendations of the report have been implemented during the past fifteen years and points to some of the problems which still await solution. The reprint is to be welcomed as making readily available to a further generation of those responsible for the ordering of the national effort in scientific research and development in Britain, no less than in the United States, the clear and creative thinking of a distinguished group of experienced and responsible scientists. The report is obtainable from the National Science Foundation, Washington, D.C.

IGY Bulletin

With the July issue (Number 37, 1960) the *IGY Bulletin* entered its fourth year of publication. The original aim of the *Bulletin* was primarily to keep participating scientists informed of progress in the United States programme, and to a limited extent, in programmes of other countries, but a large number of students, teachers and other interested persons expressed interest in the work and near the end of its first year of publication the *Bulletin* was made available on a subscription basis. The observational phase of the International Geophysical Year ended on December 31, 1958, but the programmes were continued during 1959 and have been succeeded by world-wide geophysics and space-science programmes. The great body of accumulated data still requires analysis, and the *IGY Bulletin* is being continued in order to complete the record of reports of the International Geophysical Year and the related studies, and of investigations in geophysics and space research as they become available. The *Bulletin* is also re-printed in the *Transactions of the American Geophysical Union*.

The Weizmann Institute of Science

The annual report for 1958–59 of the Weizmann Institute of Science records a steady increase in support, and the president, Abba Eban, records the intention in 1960 to explore the potentialities of science and technology in the development of new independent States, especially in Asia and Africa (Pp. 108. Rehovoth, Israel: Weizmann Institute of Science, 1960). Of the scientific activities, Prof. A. M. J. Schmidt, chairman of the scientific committee, refers to the expansion of the two-year-old programme of virological research in the Department of Experimental Biology; the exploitation by nuclear physicists of the possibilities offered by the Van de Graaff accelerator for designing experiments along new lines; the growing demands on the electronic computer *Weizac*, to growing international interest in the work of the Biophysics Department; and to the pooling of resources by scientists in the Departments of Biochemistry, Biophysics, Experimental Biology and X-Ray Crystallography for a major collaborative effort in molecular biology. Much thought has been given to the founding and work of Yeda, a research and development corporation, to foster the commercial exploitation of discoveries made in the Institute's laboratories and to provide stimulus by closer contact with the scientific problems of industry. At the Graduate School in the Natural Sciences there are now seventy-five research students, and eighteen obtained their Ph.D. degree during the year. Besides brief accounts of some of the investigations in progress in the various Departments, the report includes a list of scientific, administrative and technical staff. A list of papers published by members of the scientific staff, 1958–59, has been issued simultaneously with this annual report, but independently, and the library has also issued a definitive edition of "Serial Holdings of the Weizmann Institute of Science, 1959".

An Investigation on Mounting Boards

Recently a report concerning mounting boards has been made by the Fibre Research Institute of the Central Netherlands Organization for Applied Scientific Research at Delft at the request of the Dutch Museums Association. The *Museums Journal* for August, 1960, contains extensive notes from this report. In the past little has been known about the precise properties required in this type of board and it was considered useful to investigate various widely differing boards and so provide a basis for a set of standards. The properties which mounting boards should possess were considered under various headings and include flatness, colour, opacity, resistance to light, polluted air and micro-organisms, durability, strength, bulk and stiffness. The report makes some definite recommendations concerning the factors on which information was sought and the paper quoted gives these in some detail. It is interesting to note, for example, that the board should be free of ground wood and be manufactured from good-quality bleached pulp. For this, unused rags and soft-wood sulphate pulp bleached by the chlorine dioxide process are acceptable.

Bibliography of British Archæology

The Council for British Archæology has produced "A Booklist", slim and paper backed, with 41 pages of book titles and with very occasional explanatory notes as to their contents (Pp. 43. (London: Council for British Archæology, 10 Bolton Gardens, S.W.5, 1960.) 5*s*. 6*d*.). These are divided into sections dealing with: (1) Periods—from the Palæolithic to the Industrial Revolution; (2) Regional books, covering England, Scotland and Wales; (3) Books for children, and a short section of regional studies of a more elementary nature. The list is intended to help those of all ages who wish to take an intelligent interest in the past of Great Britain whether it be the Stone Ages, the Roman Period, the Gothic architecture, the domestic building or the furniture, clothes, crafts, silver or ceramics which interest them most. It is not stated who is responsible for the selection of titles.

Sinhalese Sports and Pastimes

Athletics have always been popular, but there has often been held an erroneous idea that activities such as wrestling and the like were mainly sports indulged in by peoples living in the more western and northerly parts of Europe. Dr. P. E. P. Deraniyagala, director of the National Museums in Ceylon, has now shown in his fascinating volume "Some

Sinhala Combative, Field and Aquatic Sports and Games", published by the National Museums, that all these activities flourished in Ceylon even many centuries ago (Pp. 51+5 plates. Colombo: Department of National Museums, 1959. Rs. 2.00). The illustrations are delightful, and it is perhaps surprising to see that when wrestling the pulling of one's opponent's long hair was permissible. In one illustration this is being done by the hands, in another by the feet. Besides wrestling there are accounts of combats between men and animals, and also bull-fighting and cocking. Hunting, falconry, horse racing and bull racing are mentioned, as well as a number of field and water games. Those keen on sports generally will be very interested to peruse this revised edition of Dr. Deraniyagala's important work.

Gyromagnetic Ratio of the Proton

In order that all measurements of the intensity of the geomagnetic field, made by investigators and observers throughout the world, might be referred to the same fundamental physical constant, the following recommendations were made by the Association of Geomagnetism and Aeronomy, International Union of Geodesy and Geophysics, at the twelfth general assembly of the Union in Helsinki, Finland, during July 25–August 6: "The International Association of Geomagnetism and Aeronomy, considering the need for a universal agreement regarding the value of the gyromagnetic ratio of the proton for measurements of the geomagnetic field, strongly recommends that, pending the agreement and specification by an appropriate international scientific organization of a final value, all measurements of the geomagnetic field with a proton free-precession magnetometer, using pure water as a proton sample, shall be based on the following value of the gyromagnetic ratio: $2{\cdot}67513 \times 10^4$ radians/gauss sec.".

Classification of Mental Disorders

Psychiatrists disagree about the concepts on which a classification of mental disorders should be based; hence the many classifications, and the frequent description of the same or similar conditions under a confusing variety of names. The effect of this diversity of classifications has been to defeat attempts at comparing psychiatric observations and the results of treatment in different countries, or even in different centres of the same country. In recent years the epidemiological approach to mental disorders has been more and more employed. To be used successfully and on a wide scale such an approach requires a common basic terminology and classification. As a first step towards this, Prof. E. Stengel, of the University of Sheffield, has examined the classifications in current use ("Classification of Mental Disorders", by E. Stengel. Offprint from *Bull. World Health Org.*, **21**; 1960. 3*s*. 6*d*. 0.60 dollars. Sw. Fr. 2). He shows that some of the difficulties created by present-day lack of knowledge are surmountable by the use of "operational definitions", and outlines the basic principles on which a generally acceptable international classification could be constructed.

Tissue Injury by High-frequency Electric Current

Ian K. Buckley, of the Department of Pathology, University of Melbourne, has employed high-frequency current to produce minute injuries to selected blood vessels within Sandison-Clark rabbit ear-chambers. There are two principal findings, which he outlines in the June edition of the *Australian Journal of Experimental Biology and Medical Science*. First, at the surface of injured endothelial cells, transparent blister-like structures appear which, after increasing in size, separate from the cell as transparent globular bodies, floating freely in the plasma. He concluded that these structures are produced by the damaged endothelial cells. Secondly, the area of vascular damage apparent within 1 hr. of injury is increased five-fold by 24 hr. It is suggested that the initially injured cells may release diffusible chemical factors which secondarily injure the surrounding endothelial cells. Alternatively, or perhaps additionally, this phenomenon may be due to initial latent cell injury which only gradually becomes visible with the passage of time. Further consequences of cellular injury were the very rapid formation of cytoplasmic vacuoles by some cells and the active migration of granular leucocytes to the site of the injury. Leucocyte accumulation under these conditions strongly suggests a chemotactic effect by products of injured cells.

Blast Disease of Oil Palm

In Central and West African oil palm (*Elaeis guineensis*) growing regions, a severe nursery root disease, occurring at the end of the rainy season and known as 'blast', has caused serious losses and dislocation of field planting schedules during recent years. The diagnosis of the disease has proved to be difficult and troublesome. J. S. Robertson, of the West African Institute for Oil Palm Research, Nigeria, has now attributed the disease to the co-infection of roots by a species of *Pythium* and *Rhizoctonia lamellifera* (*Trans. Brit. Myc. Soc.*, 42, 401; 1959). The leaf and root symptoms of blast disease are described. Isolations from roots in an advanced state of decay yielded *Rhizoctonia lamellifera*, whereas isolations from primary infections yielded a *Pythium* species. Inoculation experiments are reported which demonstrate that typical blast symptoms develop only when a mixed inoculum of *R. lamellifera* and *Pythium* sp. is employed. A laboratory experiment showed that *R. lamellifera* is capable of parasitizing the *Pythium* species.

National Certificates in Biology

In view of the increasing measure of support for courses leading to the award of endorsed certificates in biology, and of the growing importance of this subject in industry and public services, the Secretary of State for Scotland and the Institute of Biology have agreed that the stage has been reached at which a national scheme in Scotland should be introduced. They have accordingly decided to appoint a joint committee, representative of the Institute and the Scottish Education Department, to receive and approve schemes for Ordinary and Higher National Certificates in biology. This is discussed in a recent issue of the *Journal of the Institute of Biology* (7, No. 3; July 1960). The Joint Committee is preparing instructions supplementary to those already provided for other National Certificates for the guidance of colleges wishing to submit schemes. Copies of these instructions may be obtained on application to the Joint Secretary, Joint Committee for Biology, Room 365, St. Andrew's House, Edinburgh 1.

The Tarlton Rayment Collection of Australian Insects

Mr. Tarlton Rayment recently donated his collection of Australian bees, wasps, thrips and mites to

the Commonwealth Scientific and Industrial Research Organization. These will be added to the comprehensive collection of the Organization's Division of Entomology and will become part of the Australian National Insect Collection. Mr. Rayment has earned world-wide recognition as an authority in the Hymenoptera, especially the Aphidae, both for his work in classifying the Australian species of the latter, and for his interesting studies on their biology. The collection is regarded as a very important addition to the National Collection as it contains many type specimens and hence will be widely used for reference work.

Harkness Fellowships of the Commonwealth Fund

THIRTY Harkness Fellowships of the Commonwealth Fund are tenable for 1961 in Continental United States and are offered, in separate series, to candidates from the United Kingdom, Australia and New Zealand, and Western Europe. The Fellowships are offered to candidates from the United Kingdom who are British subjects and either are graduates or have experience in government service, the professions, the creative arts, journalism, branches of business or industry, or other comparable careers and vocations, and have the equivalent of a degree in qualifications conferred by professional bodies or an attested level of professional accomplishment. Forms of application, which must be returned before December 1, can be obtained from the Warden, Harkness House, 38 Upper Brook Street, London, W.1, from whom further details can be obtained.

The Association of Consulting Scientists

THE following have been elected honorary officers and members of the Council of the Association of Consulting Scientists for 1960–61: *Chairman*, Dr. J. G. Davis; *Honorary Treasurer*, Dr. G. W. Ferguson; *Honorary Secretary*, Mr. W. H. Stevens; *Members*, Dr. M. Barent, Dr. H. H. Chambers, Dr. J. Grant, Dr. J. H. Oliver, Mr. O. W. Roskill, Mr. F. G. Sarel Whitfield.

Medical Research Council: Tropical Medicine Research Board

THE Medical Research Council recently established a Tropical Medicine Research Board to advise them on the promotion and co-ordination of all research in this field. The membership of the Board includes the following: Sir Harold Himsworth (chairman); Prof. A. C. Frazer (vice-chairman); Brigadier Sir John Boyd; Prof. P. C. C. Garnham; Prof. W. E. Kershaw; Dr. R. Lewthwaite; Prof. G. Macdonald; Prof. B. G. Maegraith; Prof. B. S. Platt; Prof. M. L. Rosenheim; Mr. H. J. Seddon; Prof. E. T. C. Spooner; Prof. A. W. Woodruff; Dr. B. S. Lush (secretary). The Chief Medical Officer and the Head of the Research Department of the Colonial Office have been appointed assessors on the Board, and two assessors have been nominated by the Secretary of State for Commonwealth Relations.

Medical Research Council: New Members

THE Committee of Privy Council for Medical Research has re-appointed the Right Hon. the Earl of Limerick and, in succession to Sir Geoffrey Vickers, have appointed Dr. E. F. Collingwood to membership of the Medical Research Council. Lord Limerick will continue as chairman of the Council and Dr. Collingwood will serve as treasurer. Prof. T. Crawford and Prof. W. M. Millar have been appointed members of the Council in succession to Prof. G. Payling Wright and J. D. N. Hill, who are retiring after their normal four-year term of service. All these appointments dated from October 1, 1960.

Announcements

PROF. B. BLEANEY and Dr. James Cook have been appointed members of the Council for Scientific and Industrial Research. Together with a third member yet to be appointed, they succeed Prof. P. M. S. Blackett, Sir Eric Ashby and Mr. H. Douglass, who have retired on completion of their period of service.

DR. J. M. WINTERBOTTOM has been appointed director of the Percy Fitzpatrick Institute of African Ornithology, University of Cape Town, and took up his office there on September 1.

DR. W. S. STILES has been elected president of the Illuminating Engineering Society for 1960–61. Dr. Stiles is a deputy chief scientific officer at the National Physical Laboratory, which he joined in 1925. His work in the past has included problems of vision, photometry, illuminating engineering, and visual response by psychophysical methods; his discovery with Dr. B. H. Crawford of the directional sensitivity of the retina being his best-known contribution. He was elected to fellowship of the Royal Society in 1957 for his work on vision.

THE first major exhibition on atomic energy to be held in Edinburgh opened at the Royal Scottish Museum on October 15. The exhibition, which has been mounted by the Atomic Energy Authority, will continue until October 29; it will provide a comprehensive review of Britain's nuclear power programme and of Scotland's contribution to this major scientific and industrial effort. The exhibition will illustrate the way in which Britain's research and development resources are being deployed to meet the future power needs. These are likely to be well over double the present level, expressed in terms of coal equivalent, by 1975.

THE ninth International Colloquium on Spectroscopy will be held at Lyon during June 5–10, 1961, under the auspices of the 'Groupement pour l'Avancement des Méthodes Spectrographiques'. Further information is available from Groupement pour l'Avancement des Méthodes Spectrographiques L.N.E., 1, rue Gaston-Boissier, Paris 15e.

THE twenty-first International Conference of Pure and Applied Chemistry will be held during August 2–5, 1961, and will be followed by the eighteenth International Congress of Pure and Applied Chemistry during August 6–12. Both meetings will be held in Montreal. Further information is available from the Secretariat, National Research Council, Ottawa, Canada.

A THREE-DAY symposium on Control of the Mind is being organized by the Medical Center of the University of California at San Francisco during January 28–30, 1961. The symposium is being organized with financial aid from the Schering Foundation. Further information can be obtained from the Department of Continuing Education in Medicine, University of California, Medical Center, San Francisco 22.

ORGANIZATION AND FINANCING OF BIOCHEMICAL RESEARCH IN BRITAIN

A JOINT session of the Biochemical Society and Section I (Physiology and Biochemistry) of the British Association was held in the Department of Biochemistry, University College, Newport Road, Cardiff, during the afternoon of September 7, the closing day of the annual meeting of the British Association. The session was organized on behalf of the Biochemical Society by K. S. Dodgson and W. J. Whelan and took the form of a colloquium, with contributions by nine principal speakers, on "The Organization and Financing of Research in Biochemistry and Allied Sciences in Great Britain". The meeting was under the chairmanship of Prof. John Pryde and was attended by about a hundred members of the two organizations.

Prof. A. Haddow, director of the Chester Beatty Research Institute, introduced the subject in a general way, pointing out the unfavourable and widening gap between the research efforts of Britain and those of the United States and the Soviet Union, and then turned more specifically to the organization and financing of the British Empire Cancer Campaign. Dr. F. J. C. Herrald, Sir William Slater and Mr. C. Jolliffe described the activities of the Medical Research Council, Agricultural Research Council and Department of Scientific and Industrial Research respectively, while Dr. G. F. Marrian gave an interesting account of the work of the Imperial Cancer Research Fund and of the new research laboratories now under construction in Lincoln's Inn Fields. Prof. F. C. Happold had collated information from professors of biochemistry in Britain, and spoke of the problems, particularly financial, which are facing university biochemists. The activities of industry (particularly the pharmaceutical industry) in the field of biochemistry were outlined by Dr. F. A. Robinson, of Allen and Hanburys, Ltd., while Dr. J. B. Bateman, deputy scientific attaché to the American Embassy, spoke of the contributions of the United States in providing support for biochemistry and related sciences in Britain. Finally, Prof. A. Neuberger summarized the proceedings and pointed to the steps which need to be taken if Britain is to maintain its high position in the field of biochemical research.

Contacts with numerous members of the audience prior to the meeting suggested that the real problems surrounding biochemical research are financial rather than organizational. In this connexion, a glance at the list of participants might have indicated that the speakers could be separated into two categories, namely, those distributing financial aid and those receiving it. The possibility of the meeting dividing sharply into two factions thus existed but, happily, did not materialize. Indeed, there was a general appreciation of the considerable assistance which various bodies have provided for all fields of biological research with the funds at their disposal, and of the sympathetic way in which applications are handled by them. In turn, it was clear that officials of these bodies are well aware of the problems facing research biochemists, particularly those working within the universities.

Several points of importance emerged during the course of the meeting. In the first place, it was clear from figures presented by Prof. Haddow that, in spite of the difficulty of translating the currency figures of various countries into absolute and meaningful terms, there is a widening gap between the amount of financial aid available for research in biological and medical sciences in Britain compared with that available in the United States or the U.S.S.R. Prof. Haddow reminded his audience of the blunt words of Sir Harry Melville earlier this year: "Whether we like it or not, the age of string and sealing wax has come to an end, and the pursuit of scientific knowledge is now a rather expensive and complex affair in which substantial resources in men, material and facilities are needed". Apart from the discrepancy in financial effort, there is also some degree of contrast between the principles applied in financing research in the United States and those applied in Britain. In the United States, money is being provided for medical research, including biochemistry, on a scale which we in Britain would regard as lavish. There is a tendency to assume that expansion on this scale must inevitably result in a dilution of scientific standards and attainments. In fact, there is increasing evidence to show that the great and rapid expansion resulting from the American system has not diluted scientific standards, but rather has elicited talent which might otherwise not have become manifest.

In contrast, financial assistance for research in Britain is not so readily available, and the case must be forcefully and compellingly presented to the appropriate organization in order to obtain the necessary financial support. In considering applications for financial assistance, the Medical Research Council, the Agricultural Research Council and the Department of Scientific and Industrial Research attach great (perhaps too much) significance to the ability and reputation of the grant-seeker and the 'timeliness and promise' of the proposed research work. However, what might appear to be of timeliness and promise at the moment may not appear so twelve months hence. Other work which appears to have little import or significance at the time (and which may therefore remain unsupported) may well provide the vital answer to a problem which develops in five or ten years time. In order to cope with this problem, so far as university departments of biochemistry and allied sciences are concerned, Prof. Happold pleaded that the universities themselves should be given more adequate sums for distribution among their departments. The distribution of such sums should be under the control of an internal university committee composed of those in a position to judge the needs. Prof. Happold pointed out that it is the universities (the source of a large proportion of the research in biochemistry and other biological sciences) which are particularly affected by inadequate financial support. Indeed, the head of a department had informed him that, "If the apparatus which has been bought with gifts from the Royal Society, the Rockefeller Foundation or the M.R.C. were taken

away from this department, I can safely say that every single major line of research at present being pursued here would stop at once". Support for Prof. Happold's plea came from the body of the meeting during discussion periods, and it was clear that a strong feeling existed that university departments urgently need greater financial support from within the universities themselves.

Two further inter-related points which emerged from the colloquium were, first, that biochemistry is still primarily a research subject, and secondly, that there is already a shortage of trained biochemists in Britain. In relation to the first point, Dr. Robinson produced some interesting figures which suggested that comparatively few biochemists are employed in industry and that, generally speaking, they tend to take subordinate roles. However, Dr. Robinson did stress that his figures related particularly to the pharmaceutical industry, and it seems to the present writers that reference to other industries, for example, the food industry, might provide a more favourable picture. On the second point, Sir William Slater pointed out that it has become increasingly difficult to obtain suitably qualified research biochemists and that the brakes on the progress of the biochemical work of the Agricultural Research Council have not been shortage of funds but shortage of the right men. Further point was given to this statement by Dr. Marrian, who said that the development of the work of the Imperial Cancer Research Fund and the opening of its new Institute will mean that the number of qualified research workers employed by the Fund will increase from the present level of about 30 to between 80 and 100 by 1964–65. Approximately one-third of these will probably be biochemists. At the present rate at which trained biochemists are emerging from the universities, one suspects that Dr. Marrian will experience difficulty in recruitment on this scale.

In his summarizing remarks, Prof. Neuberger struck at the very root of this problem by pointing out that several British universities do not yet have departments of biochemistry, and he appealed to the universities to see that this defect is speedily remedied. In his own University of London, although there are a number of biochemistry departments concerned with the instruction of medical students, there are only two departments catering for a science degree in the subject, and the combined intake of these departments is limited to about twenty students a year. Prof. Neuberger further stressed the frustration felt by university biochemists of high standing who are unable to progress to senior status because of the rigidity of establishment. He pleaded for the speedy creation of new chairs of biochemistry and the introduction of personal chairs in this and related subjects. Citing the case of Harvard University, with its five professors within what is probably the best organic chemistry department in the world, Prof. Neuberger said that this is one aspect of the American university system that we should be prepared to adopt.

Bearing in mind the comments of Dr. Robinson regarding the subordinate position of biochemists in industry, Prof. Neuberger suggested that it might be time to do some re-thinking as to the way in which biochemists in Britain are trained. For example, is a training in organic chemistry being given which is sufficient for the needs of industry? Should the universities encourage the biochemist who is perhaps not ideally suited for a research position to think of a teaching post in a grammar or public school? The student population of the schools might then become more aware of the possibilities of biochemistry as a career, and this in turn might stimulate the flow of recruits to the profession.

During the two periods which were allocated to discussion, many members of the audience took the opportunity to ask questions and to state their own views. From later discussions which took place during an informal supper, it was clear that the colloquium had been a most successful venture and, in particular, many people expressed their appreciation of the co-operation of the various research councils and similar organizations in providing such interesting accounts of their activities. The meeting has raised a number of points which appear to merit further investigation and a number of problems which, it seems to the present writers, should now be actively pursued by the Biochemical Society for the good of British biochemistry and, indeed, for science as a whole.

K. S. Dodgson
J. Pryde

RESEARCH FOR INDUSTRY

"RESEARCH for Industry 1959"* follows the general pattern of the previous year's report. The report of the Industrial Grants Committee, which this year discusses the coverage of the Government scheme and co-operation in three specific areas—creep research, fatigue of metals and shipbuilding research—is accompanied by a review of the achievements of a dozen of the Associations, the terms of grant of which have been reviewed during the year; and, under "The Research Associations To-day", there is the now customary list of Associations, giving their officers, income, publications and a brief indication of the present scope of the work of each Association. To the total income of the Associations in 1959 of £7·3 million, the Department of Scientific and Industrial Research contributed £1·7 million.

In place of the two special chapters in last year's report dealing with the place of the research associations in the evolution of scientific endeavour and the service of co-operative research to the textile industry, there is a chapter by Dr. J. Thomson on instrumentation and automatic control in industry, which surveys briefly recent progress in this field in various industries, particularly under the headings of detecting elements, indicators and recorders, and controllers. The British Scientific Instrument Research Association seeks first to serve the scientific instrument industry and secondly, to bring large users of instruments into contact with manufacturers. Besides current investigations into the structure and control of thin films, of glassy phosphors, particularly

* Department of Scientific and Industrial Research. Research for Industry 1959: a Report on work done by Industrial Research Associations in the Government Scheme. Pp. iv+126+12 plates. (London: H.M. Stationery Office, 1960.) 8s. net.

as detectors of high-speed neutrons, and of the parameters of optical receiving systems with particular reference to frequency response measurements, the Association has just completed the development of an ultrasonic flowmeter, under the sponsorship of the National Research Development Corporation. The Industrial Grants Committee stresses its anxiety to foster a free exchange of information in this field between the many research associations concerned.

In regard to coverage, the Industrial Grants Committee notes that the admission of the Water Research Association, which in its new premises at Medmenham, Bucks, will be concerned with rapid methods of water filtration, algal growth in stored waters, and the disposal and reclamation of water-works sludge, brought for the first time the number of organizations in the Government scheme to fifty. Only forty-one of these bodies, however, have the formal and permanent status of a research association; the others, with the title, usually, of research council, committee or organization, being as a rule young concerns in an experimental stage. Stress is laid on the need to increase greatly the scale of research on creep. The new building being erected at the National Engineering Laboratory for completion in 1961 will permit basic researches to be expanded with the view of obtaining a better understanding of the creep process and of those properties relevant to the successful use of engineering materials at high temperatures; in the meantime, a Creep Information Centre has been opened to enable industrial designers to obtain creep data not at present readily available in a co-ordinated form. The Electrical Research Association is also planning an extended programme of tests to provide new information on those ranges of steels and temperatures of particular relevance to modern steam-raising plant and turbines, especially for generating electric power. The National Physical Laboratory will analyse and evaluate the relevant metallurgical data obtained on a range of selected steels, and co-operative creep tests are being made by several steel firms organized through a committee of the British Iron and Steel Research Association.

A committee of nine members, under the chairmanship of Sir Alfred Pugsley, has been set up to consider what research needs to be done into the fatigue of engineering structures made of metal, to survey existing research facilities and to make recommendations to the Department. In regard to shipbuilding research, besides the work of the British Shipbuilding Research Association and Parsons and Marine Engineering Turbine Research and Development Association, which is specially reviewed in the report, much useful work on ship hydrodynamics has been done at the National Physical Laboratory, and it is intended to concentrate in the new laboratory at Feltham all research and commercial tests relating to rough water and all work on steering and manœuvring problems, and to conduct smooth-water tests at Teddington. The Industrial Grants Committee is encouraging as much flexibility as possible in the programmes of the two research associations, and the report refers to the virtual completion by the British Shipbuilding Research Association of an extensive methodical series of hydrodynamic experiments on models of ocean-going merchant ship forms, the charts compiled from which should provide naval architects with a standard work of reference for estimating the resistance and power required for propulsion of any new form of ship's hull within a wide range of variables. The Association also operates an establishment for testing full-scale components of ships' structures and is concerned with all types of propelling and auxiliary machinery on ships, other than steam and gas turbines, which are dealt with by the Parsons and Marine Engineering Turbine Research and Development Association. Research and design studies by this Association have led to the production of turbine machinery of advanced design, with a 27·5 per cent reduction in overall fuel consumption and a 53 per cent reduction in the weight of marine turbines and gearing between 1945 and 1958. A special hydraulic transmission has been developed with ahead and astern units, together with a friction clutch for running ahead under steady conditions. Tests on a small steam turbine at temperatures up to 1,150° F. have yielded much valuable information, and an experimental liquid-cooled single-stage gas turbine has been designed which shows promise of giving appreciably better performances than the steam turbine. Full-scale tests of hardened and ground naval gears, and through-hardened merchant-marine gears have permitted designs of higher loading to be applied to the propulsion of merchant ships.

Among recent achievements of the British Cast Iron Research Association noted in this report may be mentioned outstanding progress in work on the causes and elimination of defects in iron castings, its development of a successful external system of dust control for stand grinders in fettling shops, the establishment of much more precise correlations between mechanical properties and structure of cast iron and between melting processes and properties, and the complete definition of the conditions for producing shock-resistant nodular cast iron. The British Steel Castings Research Association's steel-making section has constructed control curves permitting prediction, for any temperature of steel-bath and any initial oxygen content, of the amount of oxygen to be injected after the carbon flame appears in order to give a predetermined reduction in the carbon content of the bath. Other work seeks to provide basic data on the physical properties of cast steel, and the Association is also studying the control of both dust and noise when using portable fettling tools.

The File Research Council has established a maximum forging temperature by studying the metallurgical treatment of high-carbon file steel, and a study of metal flow during tooth-cutting has enabled the relation between tooth shape and chisel angles to be determined. The British Welding Research Association's tests of welded steel plates 3 ft. wide and 1 in. and 3 in. thick have established the relative importance in brittle fracture of weld defects, residual stresses, and quality of steel, and extensive work on the welding metallurgy of aluminium alloys has facilitated the selection of filler alloys. Fatigue tests have confirmed the serviceability of butt-welded pipes provided the root-run is sound and the penetration bead is smooth. The Chalk, Lime and Allied Industries Research Association, now in its fifth year, has been concerned chiefly with possible new uses for lime, the examination of factors affecting the quality of lime, and with the manufacture and use of sand-lime bricks. The Research Council of the British Whiting Federation has clearly indicated the possibility of considerable improvements in whiting manufacture by producing a range of

more uniform and finer-quality powders, and its work on quality control and grading has led to the adoption of a comprehensive system of grading by size characteristics, with limits for chemical impurities.

Basic research by the British Leather Manufacturers' Research Association in the past five years has been concerned with the hide and skin proteins and the isolation and identification of constituents of vegetable tanning materials. In applied research the advantage of sodium chlorite over sodium hypochlorite as an antiseptic in soaking has been demonstrated, and a water-proofing process developed in which the addition of rubbery polymers to the silicone solution greatly reduces the amount and cost of silicone needed. An intensive study of batch tannages in the laboratory and on the small-works scale enabled the duration of vegetable tanning to be reduced from 6–12 weeks to 14–21 days. The Hosiery and Allied Trades Research Association has given considerable help in the development of new knitting and wet-processing techniques for tailored synthetic fibre yarns, and suggested a scheme for the continuous processing of nylon hose. The British Launderers' Research Association has established the practicability of medium-temperature washing and cold-water rinsing, and has set up a Special Projects Group to investigate and develop new methods and equipment which should permit laundering on a continuous-flow basis. Psychological tests on apprentices in nineteen firms by the National Institute of Industrial Psychology have yielded a good correlation between performance at the tests and performance at technical colleges, and the tests should give a valuable forecast of probable performance during apprenticeship. Work still in progress includes inquiries into relations between satisfaction and efficiency at work, between management structure and managers' satisfaction and effectiveness in their work, methods of measuring 'personal' values relevant to people's occupations and the development of new tests of colour vision and colour-matching skills.

THE FRANKLIN INSTITUTE

At the annual meeting of the Franklin Institute held on January 20, the president, Mr. W. L. LePage, gave a summary of the activities of the Institute during 1959, and presented the annual report of the board of managers for 1959*.

The year 1959 marked the one hundred and thirty-fifth anniversary of the founding of the Institute and the twenty-fifth of its fine building on the Parkway, Philadelphia, and the report makes special mention of the remarkable growth of the Institute's activities since its modest beginning in 1824 as an organization for the mutual benefit of a few citizens of Philadelphia. To illustrate the Institute's present wide sphere of influence, the highlights of the activities for 1959 are presented in the annual report in the form of a spiral, the focus of which is taken as at the Institute's headquarters in Philadelphia and the unbroken curves of which reach out through the Delaware Valley, the nation, the world, and the universe beyond our planet. Each of these areas is taken as the title of one of the sections of the report, and the Institute's activities are discussed according to the area in which their contributions to science were the largest.

Five of the Institute's main activities—the Science Museum, the Astronomy Department, the educational radio and television programmes, the science meetings, and the Library—are confined almost entirely to Philadelphia and the Delaware Valley. The number of visitors to the Museum during 1959 was 410,433, of whom approximately 290,000 were school children. Sixteen permanent exhibitions were added during the year, of which the two most spectacular were the full-size *Matador* missile and the smoke tunnel in the Hall of Aviation. The demonstration, "Our Biggest Satellite—the Moon", which was shown in the Astronomy Department during September–October, proved extremely popular since that period coincided with the launchings of the *Lunik* II and *Lunik* III. Other exhibits included a *Vanguard* exhibit and a model of the 600-ft. radiotelescope which is being erected in Virginia. The radio and television programmes for schools in the area consisted of a weekly series of radio broadcasts covering science subjects and six television broadcasts featuring aspects of work being carried out in the Institute's laboratories. The titles of the twenty-one lectures presented at the Institute's meetings are listed in the report. They include, "The Impact of the International Geophysical Year on Science and Engineering" given by H. Odishaw; "Fundamental Particles" by H. A. Bethe; "The Fuel Cell" by H. A. Liebhafsky; and "The Science of Yesterday, To-day and To-morrow" by W. F. G. Swann. The number of accessions to the Library during the year was 4,281, bringing the total of holdings to 167,135, and the number of journals currently received rose to 1,336, including nineteen Russian journals and fourteen English translations of Russian serial publications.

In recent years the part played by the Institute in the scientific life of the United States of America has grown greatly in importance, mainly because of the work of the Institute's Laboratories and the series of technical symposia and conferences sponsored by the Institute. The symposium on space medicine electronics, held in the spring, and the international symposium on gas-lubricating bearings, held in the autumn, attracted large audiences from afar. The Computing Centre, which completed its third year of operation in 1959 and its first year as a separate activity, drastically reduced its machine-use charges and many more industrial firms availed themselves of its services. Contracts received during 1959 by the Institute's Research and Development Laboratories passed the four million dollar mark for the first time. New equipment included the latest model electron-microscope and Varian instruments used in studies of nuclear and electron-spin resonance. Projects undertaken included the production of an ultra-pure iron bar of 1-in. diameter by zone refining; apparatus to measure speed by detecting the light of an ionized gas at two points along the travel of a

*A summary and full text of the illustrated report appear in the April issue of the *Journal of the Franklin Institute* (269, 315; 1960).

wave; the preparation of a text-book on thermal stresses in nuclear reactors; and several projects related to missiles and satellites, including the design and construction of an advanced type of satellite.

By its Committee of Science and the Arts, its *Journal*, and by the work of the Biochemical Research Foundation, for which the Institute serves as trustee, the Institute is best known throughout the world. The Medal Day ceremonies organized by the Committee were held on October 21, 1959. The seventeen individual recipients included H. A. Bethe, C. H. Townes, and C. M. Zener, and one industrial company. One of the achievements of the Biochemical Research Foundation in its concentrated attack on cancer was the successful isolation of a unique streptomycin-independent strain of *E. coli* which can be used as a screening organism in a search for anti-mutagens. Long-term studies of the effects of nutrition on cancer growth were continued, as well as studies of the metabolic processes of cancer cells. In addition to the *Journal* the Institute now issues *The Institute News* eleven times a year, and although intended primarily for Institute members, this four-page newspaper is also distributed to schools, libraries and others interested in science education.

The cosmic ray group of the Bartol Research Foundation of the Institute participated in the International Geophysical Co-operation, and constructed a new cosmic ray monitor for installation at McMurdo Naval Air Facility in Antarctica, to complement the one in operation at Thule, Greenland. The detector for heavy nuclei contained in the satellite *Explorer* VII was designed by the Foundation. The Foundation's headquarters are located on the campus of Swarthmore College, and in addition to providing an active programme of scientific colloquia and public lectures, undergraduate students of the College have been encouraged to participate in the Foundation's research programme.

The report concludes by emphasizing that, though the Institute's Laboratories and the Foundation are self-supporting, the accounts indicate that the educational and general activities of the Institute, which must expand to meet the growing need, will soon face a critical financial situation. A total of approximately 204,000 dollars was received in 1959 in gifts, bequests and from other sources, but the net loss for educational and general activities, though reduced from the 1958 figure of 100,000 dollars, was still more than 20,000 dollars, and will rise as the planned expansion gets under way during the next decade. The managers of the Institute appeal to the increased generosity of members and friends of the Institute to provide the necessary additional funds.

THE ATOMIC ENERGY OF CANADA LIMITED

THE need for, and the extent of, a nuclear power programme in Canada is one of the main topics of discussion in the annual report of the Atomic Energy of Canada Limited for the year ended March 31, 1960, which has recently been published*. Although Canada has vast resources of oil, gas, coal and untapped water power, these are not uniformly distributed across the country and already some regions are approaching the point where the conventional power resources will need to be supplemented by nuclear power. The industrial area of southern Ontario is likely to be the first of these regions, and it is fortunate that conditions in this area are favourable to the early introduction of nuclear power, for not only is the generating capacity of the Hydro-Electric Power Commission which serves Ontario capable of absorbing the additional 200 or so megawatts, but also there are present in the province of Ontario extensive uranium deposits and large uranium mines.

After considerable examination of the various alternatives and several years experience in the operation of such reactors, it is still the conviction of Atomic Energy of Canada Limited that the type of reactor which is fuelled by natural uranium and moderated by heavy water offers the best promise for early, low-cost nuclear power in large units. The four nuclear power projects which the authority has in hand are described in detail in the report. The first two, the Nuclear Power Demonstration Station being built at Rolphton some twenty miles west of Chalk River, and the Douglas Point plant, are closely related. The reactor at the Nuclear Power Demonstration Station is moderated and cooled by heavy water and uses pressure tubes instead of a pressure shell to contain the coolant. The fuel consists of natural uranium dioxide pellets sheathed in 'Zircaloy' tubes, and the tubes are grouped together in bundles. The Station, which is expected to have an output of 20 MW. (electrical) and to go into operation during 1961, is a prototype, and the results of tests carried out at the Station will be used to improve and modify the design of the Douglas Point Station, the construction of which was authorized in June 1959. The clearing of the 2,300-acre site on the eastern shore of Lake Huron began in February 1960, and the Station is scheduled for completion by mid-1964. Provision has been made for two 200-MW. units, but at present only one unit *Candu* (Canadian deuterium uranium) has been authorized and is under construction.

The third nuclear project, called *Ocdre* (organic cooled, deuterium moderated, reactor experiment), consists of the development of a nuclear power reactor of medium size which it is hoped will prove attractive to industrial concerns. A preliminary report on the design of such a reactor, which was to be available in August 1960, is to include an estimate of cost of the construction of an experimental reactor. The fourth project is devoted to the study of information relating to small nuclear plants suitable for use in remote regions of Canada.

At the Chalk River Research Establishment both the *Nry* and *Nru* reactors were in routine operation during the year, being fully occupied with research experiments, the production of radioisotopes and plutonium, and engineering testing. The several 'loops' in the reactors have been used by both the United States Atomic Energy Commission and the United Kingdom Atomic Energy Authority. The

* Atomic Energy of Canada Limited. Annual Report, 1959–1960. Pp. 36. (Ottawa: Queen's Printer, 1960.) 25 cents.

two small experimental reactors, *Zeep* and *Ptr*, were also in constant operation, and a new zero energy, heavy-water moderated reactor, *Zed*-2, is being constructed and is nearing completion. One of the important lines of fundamental research carried out at Chalk River is the investigation of the structure of the atomic nucleus for which special facilities, such as the experimental reactors and particle accelerators, are provided. During the year under review major ancillary equipment was added to the 10-MeV. tandem accelerator for this particular investigation. In the Physics Division a new spectrometer, which employs the neutron beam from the *Nru* reactor as a probe to examine the forces holding together liquids and solids, was installed. The Research Chemistry Branch was mainly concerned with investigations on the breakdown of molecules exposed to intense radiation and the bombardment of metals with heavy ions. Fuel development, the physical properties of reactor materials, field tests of the method of disposal of fission products by fixing them in glass, and the development of new radiation monitoring instruments, including a tiny radiation detector which uses semiconductors, were some of the applied research problems investigated by the research establishment.

The directors and management of Atomic Energy of Canada Limited gave consideration during the year to the long-range expansion of research and development in the field of atomic energy, and recommended that Chalk River should not continue to expand, but that a new site should be selected at which future expansion could take place. In October 1959, the Government announced the establishment of a new research and development centre in Manitoba, on the east bank of the Winnipeg River between Seven Sisters and Lac du Bonnet, to be known as the Whiteshell Nuclear Research Establishment. The first major facility to be provided at the new site is likely to be the *Ocdre* reactor. During October also, Canada and Euratom signed an agreement for co-operation in the peaceful uses of atomic energy and a technical agreement for a joint programme of research and development in heavy-water reactors. A group of Euratom industrialists visited Canada in the autumn to see the various atomic energy facilities. Close co-operation with the United Kingdom Atomic Energy Authority and the United States Atomic Energy Commission continued, as well as with the authorities in Australia, Japan and Pakistan. The number of staff from other countries attached to Atomic Energy of Canada Limited during the year was sixty-two, and was limited only because of lack of working and housing accommodation. The construction of the Canada-India reactor at Trombay, India, is now essentially complete and the initial start-up is scheduled for mid-1960.

The report concludes with the financial accounts of Atomic Energy of Canada Limited and with details of the Commercial Products Division which is responsible for the production, planning, processing and marketing of the radioisotopes produced in the Chalk River reactors. More than half the curies of radioactivity sold by Canada has been for the cobalt therapy machines for the treatment of cancer which were originally developed in Canada. One hundred and eighty-five machines have been installed in thirty countries. Another device recently developed is the *Gammacell* 220, which is a portable facility for the gamma-irradiation of materials, and fourteen of these units are in service in eight countries.

CONCENTRATION OF PLANKTON PIGMENTS IN AUSTRALIAN WATERS

ESTIMATIONS of the quantity of plankton pigments are widely used as a measure of the biomass of phytoplankton. They have achieved this popularity through the ease and accuracy of the chemical estimation, and they give results more reliable than most other techniques. However, as G. F. Humphrey emphasizes in a recent paper issued by the Australian Commonwealth Scientific and Industrial Research Organization, they have many disadvantages. For example, there is a variable and uncertain relationship between pigments and the chemical composition of the organism, and so they are a poor measure of, say, the cellular carbon. Nevertheless, the pigments are the potential absorbers of the energy used in photosynthesis and the widespread usage of one particular method commends it further (Division of Fisheries and Oceanography. Technical Paper No. 9: The Concentration of Plankton Pigments in Australian Waters. Pp. 27. Melbourne: Commonwealth Scientific and Industrial Research Organization, 1960).

The author, Dr. G. F. Humphrey, who is chief of the Division of Fisheries and Oceanography, has gone to some length in perfecting a satisfactory modification of the Richards and Thompson technique for pigment measurements. He has also ascertained the precision obtained with the method, and for the analyses this amounts to $\pm$ 10 per cent, but the variation between replicate plankton samples is much larger and particularly at greater depths it is shown even to exceed previous estimates of $\pm$ 33 per cent.

The results described were obtained mainly from the Tasman Sea and in particular from two stations at 50 and 100 m. depth off Sydney. The ratios of the pigments varied during the year, with either chlorophyll *a* or *c* predominating. Chlorophyll *c* was frequently in excess and it appeared to be a pigment of major importance in the deeper waters. It should be mentioned, however, that the units used to express chlorophyll *c* values cannot be compared in absolute terms with the milligrams of chlorophyll *a*, for the specific absorption coefficient of pure chlorophyll *c* is not yet known and the determination of the actual weight of chlorophyll *c* is therefore not possible.

No smooth seasonal variation is evident in the results, but from late winter to late summer there were a series of sharp increases in pigment. There is some evidence that these peaks may be correlated with the prevailing hydrological conditions. The depth distribution suggests that the inorganic

phosphate content was inversely proportional to the chlorophyll, but neither nitrate nor total phosphate showed any correlation with the pigments.

The quantities of pigments found off Sydney covered the range found on more extensive cruises in the Coral and Tasman Seas and in the Indian Ocean. On these cruises the importance of chlorophyll *c* was again evident.

The results described in this paper are the first detailed observations of plankton pigments from Australian waters, collected in the extensive oceanographical programme which the Commonwealth Scientific and Industrial Research Organization in Australia is now undertaking, and they form an interesting basis for comparison with other regions.

R. I. Currie

CENOZOIC MAMMALS IN NORTH AMERICA

JUST over one hundred years ago Charles Moore, an amateur geologist of Bath, washed and sieved three tons of clay to obtain 30 multicusped teeth: the clay was a Rhaeto–Liassic fissure infilling and the teeth were of *Microlestes*, and they remain to-day almost the only record of this rare group of animals astride the frontier that separates mammals and reptiles.

Despite this promising beginning, few vertebrate palæontologists have taken to the labours of washing and sieving on a big scale. Dr. McKenna has been one and it has paid handsome dividends; the washing and sieving of Wasatchian claystones and sandstones has yielded him 11,000 complete mammal teeth from a formation otherwise almost barren, and a horizon astride the Eocene and Palæocene all too poorly known. The complete dissociation of the remains is a considerable limitation of the technique and Dr. M. C. McKenna does not appear to have attempted any concentrating methods, the fossils being hand picked from sieved fractions (University of California Publications in Geological Sciences. **37**, No. 1: Fossil Mammalia from the Early Wasatchian Four Mile Fauna, Eocene of Northwest Colorado. Pp. 1–130. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1960.) 2.50 dollars).

A fauna of 58 species from 12 mammalian orders is described; these include four multituberculates, a marsupial, several primates and insectivores. The fauna shows close similarity with those of early Gray Bull fauna of Wyoming, though there are notable absentees, and is considered early Wasatchian, that is, basal Eocene. The paper has no plates, but the text-figures are ample and exceptionally clear.

Pantodonta is an order of mammals the systematic study of which is fraught with difficulties; while distinction as an order is clear, the internal and external affinities remain debatable. Recent work by Dr. E. L. Simons is confined largely to the Palæocene species of North America, albeit this comprises most of the described forms; the European Eocene and Asiatic Oligocene forms are mentioned in his discussions (*Trans. Amer. Phil. Soc.* (New Series), **50**, Part 6: The Paleocene Pantodonta. Pp. 99. (Philadelphia: American Philosophical Society, 1960.) 2.50 dollars). Detailed diagnoses are given for North American Palæocene species only. The post-cranial skeleton is described for most genera where it is known, with differences noted, but few comments on their significance: although approximately half this paper is devoted to skeletal anatomy, there is only one illustration of pelves. The wealth of material available makes it difficult to accept the quotation "they [Pantodonta] defy interpretation of their mode of life because they are so totally unlike anything now living"; they are no more remote than Titanotheres and mammal-like reptiles.

Biostratonomic work threw little light on the ecology of the pantodonts; this is not surprising since their life habitat was probably quite different from their place of entombment. Concerning the relations to other orders, the author restates the main arguments used by earlier writers.

R. J. G. Savage

EARTH SATELLITE OBSERVATIONS AND THE UPPER ATMOSPHERE

Temperature Inversion in the *F*1-Layer

SUFFICIENTLY reliable values of atmospheric density—including the diurnal variations—in altitudes 200–700 km. have been derived from the variations of the acceleration of artificial Earth satellites[1–3]. Measurements from rockets[4,5] gave density values up to about 200 km.

The densities obtained from rocket measurements and the satellite data could not be represented satisfactory by a single curve with monotonically varying gradient. Therefore, H. K. Kallmann[6] suggested a model which contains a 'wiggle' in the logarithmic density curve at altitudes 150–200 km. It is model *C* in her paper.

From the data[7] from satellites 1958δ2 (*Sputnik* 3) and 1959ζ (*Discoverer* 6), it now became possible to derive the exact form of the 'wiggle'. Twenty values for atmospheric density at altitudes 180–235 km. from the satellite 1959ζ and the numerous results from the satellite 1958δ2 during August 1959–April 6, 1960, were available for this purpose. During this period the altitude of the perigee of the latter satellite decreased from 215 km. to 147 km. In order to eliminate seasonal effects, only values with $|\Delta\delta| = |\delta_\pi - \delta_\odot| < 60°$ were used (where δ is declination, π is perigee, $\odot$ is Sun).

The atmospheric densities were first derived according to a method described in detail in our earlier paper[1]; that is, preliminary values for atmospheric density were computed using the scale heights of H. K. Kallmann's "preliminary model"[6]. Then a linear approximation to the logarithmic density curve was derived graphically for altitudes where the major air drag on the satellite occurs. The gradient of this linear approximation was employed to determine the final atmospheric densities, so that we have an itera-

tion process. Because of the diurnal density variation, the gradient depends on local time. This was taken into account in the last step of the iteration.

Even the preliminary atmospheric densities derived showed a well-developed 'wiggle' in the logarithmic density curve which varied only slightly in shape when changing to the final atmospheric densities. Finally, the atmospheric densities above 180 km. were corrected to a standard value of solar activity. It is based on a flux of solar 20-cm. radiation of $S = 170 \times 10^{-22}$ W./m.^{2}c./s.

As has been shown in an earlier paper[1], the atmospheric densities are practically proportional to the flux of the 20-cm. radiation. This correlation was called the 'solar effect' or (better) 'effect of solar activity'. It has since been confirmed by L. G. Jacchia[2]. The reduction was performed using the relation :

$$\Delta \log \rho = \log \rho_{obs.} - \log \rho = \log (S/170) \qquad (1)$$

where ρ is the atmospheric density and S the solar flux at wave-length 20 cm. in units 10^{-22} W./m.^{2}c./s. The measurements were obtained by the Heinrich-Hertz-Institut, Berlin-Adlershof. We used values averaged over ten-day intervals since the satellite data also represent averages over several days. Since the solar values showed little scattering about the standard value of 170 during the period of interest, the correction had little influence on the shape of the curve.

For the ratio of mass to area we used $m/A = 40{\cdot}8$ gm.cm.$^{-2}$ for 1958δ2 and $m/A = 12{\cdot}9$ gm.cm.$^{-2}$ for 1959ζ. From this follows $AC_DF/m = 0{\cdot}0465$ cm.^{2}/gm. and $0{\cdot}154$ cm.^{2}/gm., where C_D is the drag coefficient and F a factor between $0{\cdot}9$ and $1{\cdot}0$ caused by rotation of the atmosphere, using the notation of D. G. King-Hele[3]. We found that the ratio of mass to area for the satellite 1959ζ gave atmospheric densities fitting those obtained from *Sputnik* 3 very closely.

The computed atmospheric densities are shown in Fig. 1. The circles and triangles represent the densities obtained from the *Space Track Bulletins* of *Sputnik* 3. The circles marked the data for $|\Delta\delta| < 20°$ and the triangles values for $20° < |\Delta\delta| < 60°$. The open symbols are day-time values (8–20 hr. local time), the filled symbols night-time values (20–8 hr.)

Below 170 km. the data of the Smithsonian Astrophysical Observatory deviate from the Space Track data. In this region the Smithsonian data are represented by crosses. The solid curve is valid for 14 hr. local time, the dotted curve for 6 hr. local time. Data from *Discoverer* 6 are marked by vertical crosses.

The rocket measurements by LaGow *et al.*[5] have been inserted in the diagram. The data were obtained from rocket launchings at Fort Churchill on July 29, 1957, 4.00 p.m. c.s.t. and October 31, 1958, 2.00 p.m. c.s.t., giving atmospheric densities at altitudes up to 210 km. and 188 km. respectively. These results, too, were corrected for the solar effect. The daily averages of the 20-cm. radiation were $S = 256$ and 188 after calibration (letter from the Heinrich-Hertz-Institut).

As will be seen, the 'solar effect' originates in the region of the 'wiggle' ($F1$-layer of the ionosphere) as a result of absorption of ultra-violet radiation. At 150 km. the influence on the atmospheric density becomes negligible. Thus the rocket data for $h \geqslant 180$ km. were corrected using equation (1) ; the data for $150 < h < 180$ km. were corrected using the following relation :

$$\Delta \log \rho = \frac{1}{30} (h_{km.} - 150) \cdot \log (S/170) \qquad (2)$$

Thus we obtained an increase in the correction from 0 at 150 km. to the full value at 180 km.

The agreement between the rocket data and the curve is excellent. In interpreting the data, however, one has to take into account the position of the rockets in 59° north latitude, with $\Delta\delta = 40°$ on July 29, 1957, and $\Delta\delta = 73°$ on October 31, 1958.

The very close correlation between atmospheric density variations ($h > 180$ km.) and the solar 20-cm. radiation emitted from the hot condensations of the solar corona points to the fact that the origin of the solar effect may lie in the absorption of solar ultra-violet radiation, which is also part of the thermal emission of the hot condensations. The Lyman alpha line of He$^+$ (304 Å.) may be mainly responsible for that, because of the high ionization potential of helium. H. E. Hinteregger *et al.*[9] were able to measure the absorptions of the He$^+$ line in altitudes 150–210 km. from a rocket on March 12, 1959. From their results we find that the Earth's atmosphere has at 304 Å. an optical thickness $\tau \approx 0{\cdot}1$ at 210 km. but $\tau = 1$ at 160 km. The increase in optical thickness is almost linear in the log τ, h diagram for altitudes 210–150 km. At 150 km. the He$^+$ line is almost completely absorbed.

From the atmospheric density curve between 180 and 200 km. we find a temperature inversion in the $F1$-layer. The quantitative representation of the

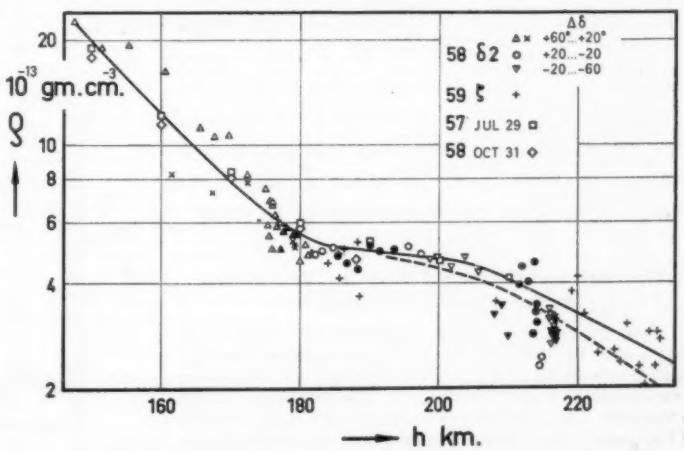

Fig. 1. Atmospheric densities at altitudes 150–230 km. above the Earth ellipsoid. The solid line refers to 14 hr. local time, the dotted line to 6 hr. local time. The results were obtained from the satellites 1958δ2, 1959ζ and the rocket launchings (ref. 5) of July 29, 1957, and October 31, 1958. The results from 1958δ2 are subdivided into three groups according to their $\Delta\delta$-values ($\Delta\delta = \delta_\pi - \delta_\odot$) (where δ is declination, π is perigee, $\odot$ is Sun). Open symbols give day-time values (8–20 hr. t.l.t.) ; filled symbols give night-time values (20–8 hr.)

temperature will be given elsewhere[10]. Because of the small heat conduction at 200 km. the density curve changes little between day and night (see Fig. 1).

It is not possible at present to decide whether solar ultra-violet radiation as well as the solar He^+ line and solar X-ray radiation contribute to the heating of the $F1$-layer. Furthermore, heating by a steady flux of solar corpuscular radiation may be expected at 200 km. according to L. G. Jacchia's observations on satellite 1958β1 during the magnetic storms of July 1958 and September 1958. The diurnal variation of atmospheric density may indicate a contribution of corpuscular radiation to the heating (see ref. 11, Fig. 1). The increase in density seems to start before sunrise; that cannot be explained by electromagnetic radiation. However, because of the large scattering of the values, this result seems unreliable.

A second 'wiggle' depending on solar activity may be expected in the E-layer. It remains to be shown whether it has an observable value. A third 'wiggle' could be expected at 300–500 km. ($F2$-layer). It will be smoothed out by the large heat conductivity that has been deduced by M. Nicolet[12]. This problem will be discussed in more detail in the following communication[11].

We are grateful to Dr. H. K. Kallmann, who suggested this problem, and to Mr. D. G. King-Hele for discussion of the data of *Discoverer* 6.

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Diurnal and Seasonal Density Variations in the Upper Atmosphere

Continuing our earlier investigations[1,2], we have been able to derive the diurnal and seasonal density variations at altitudes of 210, 562 and 660 km. from variations in the acceleration of the satellites 1958β2 (*Sputnik* 3), 1959α1 (*Vanguard* 2) and 1958β2 (*Vanguard* 1). The computation of atmospheric densities by an iteration process has been described in the preceding communication and will be given in detail in a subsequent publication[3]. The air densities given in Figs. 1–3 are the final values obtained after the last step in the iteration process.

The numerous values of atmospheric density from satellite 1958β2 were grouped according to their dependence on $\Delta\alpha$ and $\Delta\delta$ respectively since the variations of density are relatively small at 210 km. above the Earth ellipsoid. The differences $\Delta\alpha$ and $\Delta\delta$ are defined by $\Delta\alpha = \alpha_\pi - \alpha_\odot$, $\Delta\delta = \delta_\pi - \delta_\odot$ (where α is right ascension, δ is declination, π is perigee, $\odot$ is Sun).

The diurnal variation of density is a function of $\Delta\alpha$ and thus of true local time. Since during the lifetime of the satellite $\Delta\alpha$ traversed 360° eight times, the group averages of the diurnal variations are taken from different dates within the period May 15, 1958–October 1, 1959. Observations of the last six months of the satellite, during which its perigee traversed the 'wiggle' of the $F1$-layer, were not included in the derivation of the group averages. The seasonal effect is a function of $\Delta\delta$. The group averages are plotted in Fig. 1. The diurnal variation curves for $\Delta\delta = 0°$ and $-40°$ were obtained with the aid of a special adjusting method using all group averages.

The variation of the atmospheric density at 562 km. above the Earth elipsoid is plotted in Fig. 2. These results were obtained from satellite 1959α1, and each

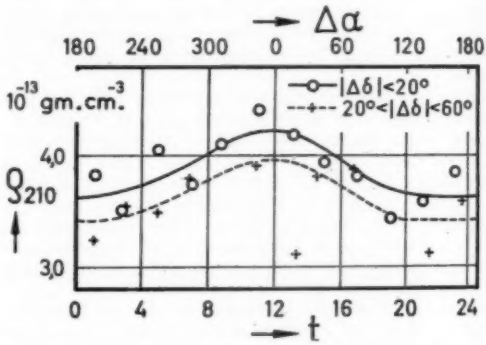

Fig. 1. Diurnal and seasonal variations in atmospheric density at 210 km. derived from observations of the satellite 1958β2. The lower x-scale gives true local time, the upper $\Delta\alpha = \alpha_\pi - \alpha_\odot$. The parameter of the curves is $\Delta\delta = \delta_\pi - \delta_\odot$, where α is right ascension, δ is declination, π is perigee, $\odot$ is Sun

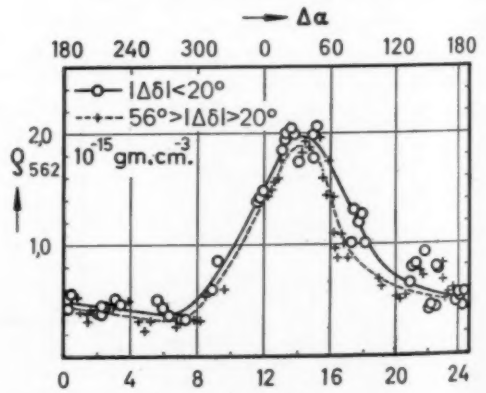

Fig. 2. Variations in atmospheric density at 562 km. above the Earth ellipsoid derived from the observations of satellite 1959α1. Scales as in Fig. 1

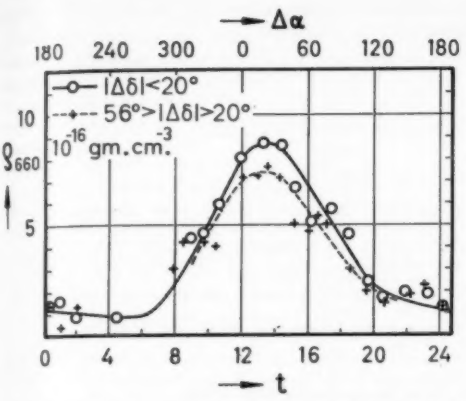

Fig. 3. Variations in atmospheric density at 660 km. derived from the observations of satellite 1958β2. Scales as in Fig. 1

one is plotted. They are derived from the orbital elements of the Smithsonian Astrophysical Observatory and the dP/dt values by L. G. Jacchia[4].

The variation of the atmospheric density at 660 km. was obtained from the orbital elements of the satellite 1958β2 (Fig. 3) (Orbital elements by NASA Computing Center, dP/dt values by L. G. Jacchia[5]). Each dot represents a group average. All diurnal variation curves have similar shapes, especially at high altitudes. The peak of density is reached at about 14 hr. true local time. Then a steep decline follows until sunset. During the night, the density continues to decline though more slowly and almost linearly. After sunrise the curve begins to rise steeply until it reaches its peak.

The amplitude of the variation increases with increasing altitude. Above 300 km. it becomes the most important characteristic of the atmospheric model. In Fig. 4 the variation of atmospheric density is plotted against true local time for the zone $|\Delta\delta| < 20°$. The model was obtained using the curve shown in Fig. 2. This curve was selected because it was obtained from results between February 24, 1959, and March 20, 1960. During this period, the 20-cm. observations obtained by the Heinrich-Hertz-Institut, Berlin-Adlershof, showed no intense drifts of long duration as was the case in 1958. An explanation of the drift in 1958 has not yet been given. M. Nicolet[6] assumes that the drift results from instrumental errors; this means, however, that in order to understand the satellite observations one must postulate an important effect of unknown cause the variation of which corresponds to the variation in the 20-cm. radiation (see also L. G. Jacchia[4]).

The shape of the curves in Figs. 2 and 3 as functions of the position of the Sun (local time) shows clearly that the diurnal variation results from the absorption of electromagnetic radiation (ultra-violet-radiation) and from heat conduction, which is very rapid at high altitudes. The diurnal variations which occur at altitudes higher than 250 km. cannot result from the heating by absorption of the He$^+$ line 304 Å. at 200 km. because heat conduction is very slow at this altitude. Thus one may conclude that a further absorption of high-energy solar radiation occurs at altitudes 300–500 km., possibly in the $F2$-layer. Because of the rapid heat conduction, no well-developed 'wiggle' is to be expected. The day-time heating simply results in a larger curvature of the logarithmic curve of density. This may be seen in comparing the curvatures above 400 km. for 14 hr. and 6 hr. in Fig. 4. The effect of both heating and heat conduction results in the 'fan shape' of the density model (Fig. 4).

The isothermal atmosphere which is caused by rapid heat conduction begins above 500 km. The temperature there is a function of local time analogous to the density function. One may suppose that the heating results mainly from the absorption of the helium line at 584 Å. at altitudes of 300–500 km. The line was barely detectable at 210 km. according to measurements by H. E. Hinteregger *et al.*[7]. Measurements of the solar ultra-violet radiation and the X-ray spectrum between 300 and 500 km. are urgently needed. At the same time, measurements of the helium content of the upper atmosphere would be highly desirable.

The diurnal variation of density for $|\Delta\delta| > 20°$ gives an insufficiently uniform picture. Furthermore, from the above theory we must expect the density to be a function of geographical latitude as well as $\Delta\delta$.

The physical condition in the upper atmosphere may be summarized in the following simplified picture: The 'solar effect' originates in the $F1$-layer as a result of heating by the solar He$^+$ line at 304 Å. This explains the good correlation between density variations above 200 km. and solar decimetre radiation

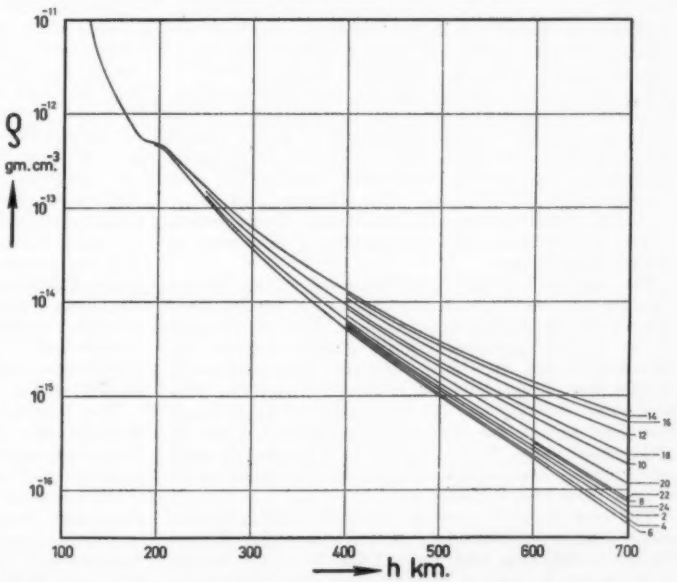

Fig. 4. Diurnal variations of the atmospheric density at altitudes 150–700 km. above the Earth ellipsoid for $|\Delta\delta| < 20°$. All values are corrected to mean solar activity (solar flux of 20-cm. radiation $S = 170 \times 10^{-22}$ W./m.^{2} c./s.). The parameter ot the curve gives the true local time. In addition to the satellites mentioned in the text, we used 1958α and 1958ε in computing this atmospheric density model

(3–30 cm.). The period of the density variations agrees largely with the rotational period of the Sun. The heating of the $F1$-layer determines the boundary conditions for the upper atmosphere at 210 km. This explains why the logarithmic curves for density appear to be shifted parallel as a function of 20-cm. radiation (see ref. 1, Fig. 10). The diurnal variation of density at 210 km. is only a few per cent. Absorption of solar electromagnetic radiation in the $F2$-layer together with the large heat conductivity cause the intense diurnal density and temperature variations above 300 km. ('fan shape' of the air density model, Fig. 4).

We gratefully acknowledge the continuing dispatch of 20-cm. data by the Heinrich-Hertz-Institut, Berlin-Adlershof, prior to publication. We are also indebted to Dr. H. K. Paetzold for unpublished dP/dt values of *Sputnik* 3. Furthermore, we wish to thank the Space Track Center and the Smithsonian Astrophysical Observatory for supplying the orbital elements.

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SOME GEOCHEMICAL ASPECTS OF A COLUMBITE-BEARING SODA GRANITE FROM SOUTH-EAST UGANDA

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As part of the exploratory programme of the Research Institute of African Geology in the University of Leeds, a unique radioactive soda granite from the Lunyo area in south-east Uganda has been investigated. This granite was first recorded and named the Lunyo granite by Dr. K. A. Davies[1], a former director of the Uganda Geological Survey. Late in 1951 a number of specimens of the Lunyo granite were examined in this Institute, and at the request of Dr. Davies a mineral separation was carried out in order to analyse an unusual mica in the granite. The mica was identified as zinnwaldite, rich in lithium and with an exceptionally high fluorine content. During 1956 the concentrates of the Lunyo granite were re-examined, and in addition to the main magnetite and zircon, columbite, cassiterite and thorogummite were found. The discovery of these important accessories prompted a closer investigation of the Lunyo area, and a summary of this work is communicated here.

The general geological configuration of south-east Uganda has been previously described by Davies[1]. Subsequent geological observations have shown that the main rock types occurring within this region can be conveniently correlated with the Nyanzian rocks on the eastern side of Lake Victoria in Kenya. The minimum absolute age for the Nyanzian as deduced from lead isotope determinations in galena is 2,200 ± 150 million years. The rocks of the Nyanzian System are therefore comparable in age with the oldest rocks known from the Precambrian.

The area under discussion lies in the south-easternmost corner of Uganda, bounded by the Kenya border to the east and Lake Victoria to the south. Granitic and dioritic rocks constitute the main geological element, and are seen to be intrusive into remnants of older supracrustal rocks comprising leptites and amphibolites with an east–west trend. The Lunyo granite is exposed in a few separate units occupying a total area of some 10 sq. miles.

The following tentative geological succession has been established in the area: 1, leptites and amphibolites; 2, granodiorites; 3, Lunyo granite; 4, Masaba granite; 5, late doleritic dykes.

The leptites are the metamorphic equivalents of Precambrian acid volcanics, usually of rhyolitic–dacitic composition. Banded structures consisting of coarse- and fine-grained layers suggesting alternating lava and tuff material are frequently seen. Among the leptite varieties there may be both soda and potash extremes, as well as rocks with a silica content greater than 80 per cent. The leptites in this area are generally porphyritic meta-dacites and are dominantly soda-bearing. The highest metamorphism attained corresponds to the amphibolite facies. The volcanic character of these rocks is very apparent and, in places hypabyssal equivalents, either fine-grained felsites or coarser feldspar porphyries, are observed. Some of the leptites have conspicuous corroded phenocrysts of sapphire-blue quartz, a feature which persists over wide areas. Pyrite and pyrrhotine mineralization is widespread among the leptitic rocks.

The meta-rhyolites have been observed only in isolated hills rising above the normal flat terrain. They are extremely siliceous rocks, and in their present metamorphic state resemble fine-grained sericite schists of sedimentary origin; however, some exposures show distinct igneous flow structures, and in thin sections the rocks are seen to contain corroded bipyramidal crystals of quartz. In places, quartzites associated with these latter rocks and especially those which bear andalusite or are interbanded with graphitic shales and hæmatite ore, may well have formed under different conditions, for example,

alternating sedimentation of colloidal silica, clay and iron hydroxides in water.

The amphibolites are either interbanded with the leptites or form separate lenticular bodies. In some parts they occupy larger areas, for example, Bulamba and Isindi hills, and are frequently accompanied by coarse doleritic types. At several exposures pillow structures are developed locally, and some thin sections exhibit distinct flow texture.

The granodiorites form a characteristic group of rocks, and in one case a lenticular body extends for several miles along the southern boundary of the Lunyo granite. The granodiorites consist of lath-shaped crystals of zoned plagioclase, together with larger reddish grains of microcline-perthite, amphibole and smaller amounts of biotite and quartz. Contacts between the granodiorite and the leptites indicate a later emplacement of the former rocks, while pegmatite veinlets which apparently have been derived from the Lunyo granite are seen to intersect both the leptites, amphibolites and the associated granodiorites.

The main type of the Lunyo granite as found in the Lunyo hill area is a leucocratic, medium-grained rock, with a distinct foliation produced by the parallelism of ellipsoidal quartz grains, especially clearly seen on the weathered rock surface.

Observations in the field show, however, considerable variations both in colour and size of grain, and often the granite appears to be porphyritic with large, rounded phenocrysts of quartz, angular porphyroblasts of feldspar and aggregates of mica set in a fine-grained matrix of albite.

Direct contacts with surrounding granites or other rock types have not been observed. In many places within the Lunyo granite, pods and schlieren of greisen are common. These are at times of considerable size and consist mainly of a fine-grained greenish-yellow mica (phengite) with some feldspar, quartz and variable amounts of fluorite. A partly greisenized Lunyo granite contains some 4 per cent fluorite. Pegmatites and aplites are common associates of the granite. Indeed, in places they are so numerous that the rock resembles a veined gneiss. The pegmatites occur as sheets or bands which are either cross-cutting or conformable. They are not uniform in thickness, but pinch and swell to various degrees. Zoning has been observed in some cases, but on the whole is rare. The pegmatites consist chiefly of a coarse-grained white or red microcline-perthite with varying amounts of quartz and fine-grained albite and only occasionally some mica is present. The aplites are intermixed with the pegmatites and are composed of the same minerals, but the soda/potash ratio is much higher. Microscopic examination of the Lunyo granite shows ovoid-shaped grains of quartz with highly undulose extinction and often with inclusions of minute albite laths at times in concentric arrangement. The microcline porphyroblasts almost always contain inclusions of albite, commonly aligned and forming a regular pattern, and stringers of albite in a flame-perthite fashion. Grains of a crypto-perthite, thought to be anorthoclase, also have been noted. Fine-grained albite constitutes the ground-mass, and frequently the laths are seen to be in parallel orientation. Zinnwaldite, which is the main mica of the rock, shows a distinct light-green to blue-grey pleochroism. A dark-green mica is locally present forming spherical aggregates.

The following accessory minerals have been identified so far: magnetite, columbite, cassiterite, zircon, thorogummite, fluorite and pyrite in the granite, and in addition to these betafite, kasolite, galena, zinc-blende and cerussite in the pegmatites. An interesting feature is that both the granite and the associated pegmatites, aplites and greisens contain practically the same rare-mineral assemblages.

The Masaba granite borders the Lunyo granite and the meta-volcanics to the north, east and south. The granite intrudes in the leptites and the amphibolites and forms a contact zone of hybrid rocks which retain many of the textural features of the original volcanics; they also include xenoliths of leptites and amphibolites. There does not appear to be any genetical relationships between this granite and the Lunyo granite proper, and it is perhaps significant that pegmatites are totally absent.

Late dolerite dykes cut all the previous rocks. It is often difficult, however, to distinguish these dykes from older doleritic rocks associated with the amphibolites.

A series of chemical and spectrographic analyses have been made on rocks from the Lunyo area, including various types of the Lunyo granite, aplites, meta-volcanics, granodiorites, amphibolites and other granitic rocks from the surrounding area, and a part of these results is reproduced in Table 1.

The outstanding rocks, from a geochemical point of view, are the Lunyo granite, together with the

Table 1. Chemical Analyses of Rocks from the Lunyo Area and Surroundings, South-east Uganda

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SiO_2	73·67	73·01	70·79	74·97	73·67	69·33	65·89	84·24	72·35	70·30	68·36	65·98	52·30	50·73
TiO_2	tr.	nil	nil	0·17	0·26	0·48	0·37	0·17	tr.	0·45	0·55	0·39	1·27	1·24
Al_2O_3	15·24	16·14	14·99	12·63	13·57	14·78	15·40	10·16	14·60	13·93	15·59	15·30	15·52	14·09
Fe_2O_3	0·35	1·04	0·08	0·62	0·52	0·64	1·25	0·58	0·73	1·27	0·64	1·05	1·64	6·55
FeO	0·36	0·21	0·53	0·89	1·26	2·63	1·58	0·13	1·16	3·33	2·87	2·65	9·04	6·61
MnO	0·01	0·02	0·06	0·03	0·03	0·05	0·10	tr.	0·02	0·06	0·06	0·06	0·30	0·20
MgO	0·02	tr.	tr.	0·35	0·23	1·30	2·31	0·15	0·10	1·49	1·33	1·39	4·68	6·05
CaO	0·07	0·20	3·47	1·52	0·97	3·50	2·89	tr.	1·44	4·79	2·46	3·05	11·40	10·51
Na_2O	7·04	7·11	3·38	4·15	3·66	4·78	5·05	0·29	5·79	2·60	6·00	5·36	2·47	2·48
K_2O	3·20	1·50	4·26	3·46	5·34	0·77	4·22	3·12	3·01	0·96	0·75	3·15	0·21	0·42
H_2O+	0·07	0·43	0·45	0·66	0·55	1·00	0·56	1·20	0·33	0·75	0·98	0·75	1·08	1·36
H_2O-	0·10	0·17	0·21	0·04	0·09	0·04	0·08	0·08	0·07	0·07	0·05	0·05	0·04	0·08
P_2O_5	tr.	0·13	0·05	0·07	0·12	0·48	0·20	0·03	0·07	0·19	0·13	0·61	0·08	0·14
Total	100·26	99·96	99·52	99·99	100·27	99·78	99·90	100·15	99·96	100·19	99·77	99·98	100·03	100·46

1. Lunyo granite (fresh) from Lunyo hill (Li_2O = 0·13 per cent). 2. Aplite from Nakinu. 3. Fluorite-bearing granite from Namaingo (F = 2·15 per cent; less O ≡ F = 0·90 per cent). 4. Masaba granite near Masaba (CO_2 = 0·43 per cent). 5. Buteba granite from Buteba near Busia. 6. Granite-gneiss (hybrid rock) from Nasigombe. 7. Granodiorite from Buliali. 8. Meta-rhyolite from Siavona hill. 9. Fine-grained porphyry, upper Nalioba (CO_2 = 0·29 per cent). 10. Leptite from Luangosia. 11. Leptite (soda-extreme) from Butenge. 12. Feldspar porphyry from Luangosia (S = 0·30; less O ≡ S = 0·11 per cent). 13. Amphibolite (pillow lava) from Isindi hill. 14. Dolerite from Isindi hill.

Nos. 1 and 4: analysis by O. von Knorring. Nos. 2 and 3: analysis by Mrs. E. Padget. Nos. 5, 8 and 11: analysis by Miss J. R. Baldwin. Nos. 6–7, 9–10, and 12–14: analysis by Mrs. M. H. Kerr.

Table 2. Spectrographic Analyses of Rocks from the Lunyo Area and Surroundings (in p.p.m.)
Analysis by Miss J. M. Rooke and Mrs. A. M. Fisher

	Li	Rb	Sr	Ba	Ga	Y	Zr	Pb	V	Nb	Cr	Ni
Lunyo Granite (Fresh)	>1,000	900	<30	<30	65	<30	700	50	<3	350	10	6
Lunyo Granite (Weath)	>1,000	1,000	<30	<30	70	<30	500	5	<3	170	45	10
Aplitic Granite, Bugaya	>1,000	1,300	<30	<30	85	<30	>1,000	400	<3	170	60	35
Aplitic Granite, Buliali	>1,000	1,400	<30	<30	60	<30	>1,000	45	<3	600	40	20
Fluorite Granite, Namaingo	400	1,000	60	40	45	45	>1,000	55	<3	700	40	17
Buteba Granite, Buteba	90	450	85	450	35	<30	170	30	5	<10	75	10
Masaba Granite, Masaba	8	<100	160	1,500	20	<30	130	12	8	<10	10	10
Granite-gneiss, Nasigombe	30	<100	170	200	30	<30	170	13	60	<10	40	30
Leptite, Luangosia	15	<100	100	200	30	<30	160	10	50	<10	130	110
Leptite (soda-extreme), Butenge	25	<100	250	300	30	<30	190	6	75	<10	65	30
Meta-Rhyolite, Siavona	<3	<100	<30	500	25	<30	200	14	<3	<10	45	9
Granodiorite, Buliali	18	<100	>1,000	1,300	30	<30	140	15	90	<10	350	75
Granodiorite, Budidi	40	<100	450	1,100	30	<30	200	16	100	<10	250	60
Fine-grained porphyry, Nalioba	<3	<100	450	1,300	25	<30	95	13	<3	<10	50	5

In all analyses: Be < 3, La < 100, Ge < 30, Ta < 100, Co < 10 and Mo < 3.

allied rocks within its boundaries. The chemical composition of the Lunyo granite, analysis 1, shows some affinities to the metasomatic late-kinematic ideal granites as defined by Eskola[2], providing the alkalis are reversed. Geochemically, there are marked similarities with the Nigerian younger granites, especially with the late suite of albite–riebeckite granites[3].

Among the major constituents, alumina is much higher than in ordinary granites. This is mainly due to the high soda, as there is no corresponding increase in lime. Coupled with the high soda and potash, the sum of the normative feldspars is more than 70 per cent, while the albite component is approximately 60 per cent. The cafemics are exceptionally low, and usually amount to less than 1 per cent.

Among the minor elements, lithium and rubidium are comparatively high. Spectrographic estimates of lithium and rubidium indicate that the amounts of these constituents are higher than is usual for granitic rocks, apart from those of the pegmatitic phase. Lithium is contained in zinnwaldite and other micas, and rubidium is concentrated mainly in the microcline–perthite of the pegmatites, where the rubidium content is approximately 1 per cent. Fluorine is constantly present and is abundant in the fluorite-bearing granite. In the Lunyo granite most of the fluorine is accommodated in the zinnwaldite, which carries 8 per cent fluorine. The content of beryllium is low and beryl has not been met with in the pegmatites of the area. Lead and zinc are distinctive trace elements of this complex and both are represented by independent minerals: galena, sphalerite (yellowish-green in colour), cerussite, kasolite (a lead–uranium–silicate) and an unidentified lead–uranium mineral. All these minerals have been introduced during a late stage and at relatively low temperatures. There is a much lower concentration of the rare earths as compared with the Nigerian province; consequently monazite and xenotime have not been found. The content of the trivalent gallium, however, is greater than average. Zirconium, tin and thorium are represented by the accessories zircon, cassiterite and thorogummite. The latter mineral is found in various stages of alteration and may be green, yellow, orange or brown in colour. The titanium content is exceptionally low and no independent titanium minerals have been noted. The high niobium content is a characteristic feature of the Lunyo granite and its associated pegmatites, aplites and greisens. In the granite itself the niobium content in terms of columbite varies from 0·05 to 0·1 per cent, in the greisens there is approximately 0·1 to 0·2 per cent, and in the aplites and pegmatites the columbite may be as high as 0·5 per cent. These columbite values are comparable with those of the Nigerian younger granites[4]. The Nb_2O_5/Ta_2O_5 ratio is about 13 to 1. Another niobium mineral, betafite, has been identified from various pegmatites.

In addition to the conspicuous deficiency of titanium, there is also an apparent lack of boron and phosphorus. Tourmaline and apatite appear to be absent in the Lunyo granite and its associates, and even the greisens are devoid of these minerals.

When the values for trace elements of the Lunyo granitic suite are compared with those of the surrounding rocks, the former show a completely distinct geochemical pattern (Table 2).

The characteristic textural features of the Lunyo granite, together with its position within the belt of porphyritic volcanics, strongly suggest some genetic relationship with the latter rocks. The granite is considered to have been formed by metasomatic granitization of soda-rich volcanics of the Butenge type, and the unique mineralization involving lithium, fluorine, zinc, lead, zirconium, tin, thorium, niobium and uranium in the form of accessory minerals is believed to be connected with the granitization process. The metasomatism appears to have involved little addition of soda, but potash was certainly introduced, particularly during the later stages of granitization now marked by the dominantly microcline-rich pegmatites and micaceous greisens.

The Lunyo granite, together with its pegmatites, aplites and greisens, are distinctly radioactive over large areas. The main cause of this radioactivity was initially attributed to the accessory thorogummite, but recent observations have shown that, among the accessory minerals, kasolite and betafite are of common occurrence and thus contribute to the radioactivity. A sympathetic relationship seems to exist between the important minor accessories and the radioactivity observed. Thus higher radioactivity not only denotes an increase in radioactive minerals but also indicates higher concentrations of columbite.

This work has been undertaken in close collaboration with the Geological Survey of Uganda. I am indebted to Mr. A. Cawley, director of the Geological Survey, for his assistance during field-work and permission to publish this communication.

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ULTRASONIC DEGRADATION OF WOOL AND HAIR

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ULTRASONIC vibrations have been used for the disruption of cells[1], micro-organisms[2], and for the modification of soluble proteins and amino-acids[3–5]. The evidence on wool is conflicting, since it has been reported that virgin wool is not degraded by ultrasonics[6,7], although shrink-proofing can be effected by this means[8], and Andrews[9] has since found that cuticular material is liberated. Because of the need for a purely mechanical method of degradation of the fibre (other than the laborious method recently developed[10,11]), it was decided to investigate this possibility. It is reported here that wool and hair can be degraded mechanically by ultrasonic treatment, with no appreciable amount of chemical attack, into cuticle material and cortical cells.

Two different types of ultrasonic instruments were used. The first was a 60-watt, *MSE*-Mullard ultrasonic disintegrator in which waves of 16–24 kc./s. were transmitted by a $\frac{3}{4}$-in. diameter stainless steel probe immersed directly in the solution containing the sample. Samples of wool and hair (0·05–1 gm.) were treated at < 35° about 1–4 cm. below the probe, which disintegrated slowly in aqueous solutions. The second was a 60-watt, Narda Ultrasonics Corporation, Sonblaster, series 600, in which the contents of a 3-litre capacity stainless steel tank were treated with ultrasonics at 40 kc./s. Samples of up to 10 gm. of wool and hair were treated in about 1-litre of solution which was kept at < 30° by a cooling coil.

After treatment the residual fibres were dried, snippets were cut in a representative manner and mounted in 'Sellotape'[12,13]. These were examined under the microscope and ≮ 200 classified into four different groups as follows: (0) scales undamaged, (1) slight removal of scale edges, (2) considerable removal of scale edges, (3) complete removal of scale edges. The percentage of fibres in each category was multiplied by the number in brackets and the figures summed to give a weighted total indicative of damage to the cuticle.

The milky solution obtained after treatment was centrifuged, and if the Mullard instrument had been used, metal particles were sedimented by centrifugation in 2 *M* potassium dihydrogen phosphate, 2 *M* dipotassium hydrogen phosphate solution while the protein remained suspended. The latter was weighed, examined microscopically and in a few cases amino-acid analyses were carried out by the dinitrophenylation method[11].

Samples of virgin wool ranging from Merino 90's to Lincoln 36's, and human hair were cleaned[14] and 3-gm. samples treated in the Sonblaster for 16 hr. in 500 ml. distilled water. A yield of 0·6 per cent of degraded material was obtained from each of the four samples of wool and 1·5 per cent from the human hair. The material from wool and hair consisted of about 90 per cent of small flat pieces of cuticle material and about 10 per cent of needle-like cells of sizes up to that of cortical cells. The treated fibres were examined microscopically and there was a gradation from no apparent damage with Merino 90's to a value of 62 for Lincoln 36's and 103 for human hair. This would be expected in view of the progressive decrease in the surface area to weight ratio of the fibres in this series. It is not clear why the cuticle of human hair breaks down more rapidly than that of wool, particularly as the former overlap along about 5/6 of their length compared with only about 1/6 for Lincoln wool[15].

Three-gm. samples of Lincoln 36's top were treated for 2 hr. in the Sonblaster in 500 ml. of solutions buffered at *p*H 1, 3, 5, 7, 9 and 11. The percentage yields of degraded material were 0·1, 0·1, 0·2, 0·4, 0·6 and 0·6 respectively. The rate of breakdown was not increased by treatment in concentrated ammonia or hydrazine hydrate but was rapid in 0·1 *N* sodium hydroxide, with considerable chemical degradation of the wool. Treatment in aqueous solutions of lithium bromide (100 per cent w/v), guanidine hydrochloride (50 per cent w/v), urea (sat.) or glacial acetic acid, dichloroacetic acid, formamide or dimethyl formamide produced only small changes in the amount of breakdown, but there was a large increase in 98 per cent formic acid. Breakdown was slight in organic solvents such as *n*-butanol, ethanol and a petroleum fraction, b.p. 150–200°.

Samples of Lincoln 36's top chemically modified by acid chlorination, hydrogen peroxide, reduction with sodium hydrogen sulphite or treatment with alcoholic sodium hydroxide showed no greater rate of ultrasonic breakdown during 24-hr. treatment in water using the Mullard instrument than the untreated top. Also wool from the tip of the fibre showed no difference in behaviour from that taken from the base.

Two samples of human hair treated for 4 hr. and 40 hr. in the Mullard instrument in water produced material in about 0·3 and 4 per cent yields respectively. On amino-acid analysis[11] it was found that the latter sample contained more Arg (26 per cent) Cys (29 per cent) and less Gly (19 per cent) than the former, but both were entirely proteinous. The differences may be due to the continuous mechanical degradation of the fibre, producing material of a continuously changing composition, and/or chemical degradation of the material. This point was resolved by amino-acid analyses on a finely powdered sample of Lincoln 36's top (obtained by grinding in a pestle and mortar under liquid oxygen) before and after a 40-hr. ultrasonic treatment as above. There was no detectable change in the amino-acid content after the ultrasonic treatment, hence the amount of chemical degradation was negligibly small.

The ultrasonic method should make possible a much more detailed investigation of the chemical composition and structure of the various cuticle layers of virgin and treated wools than has been possible by the descaling method[11] or by methods based on chemical degradation of the cuticle. It should also be possible to probe deeper into the wool fibre and separate chemically unchanged cortical cells for detailed investigation.

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BIAS IN BASE-PAIR ORIENTATION IN DEOXYRIBONUCLEIC ACID

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A COMPLEMENTARY base-pair within a double-helical deoxyribonucleic acid molecule may be oriented in one of two ways. This article reports the finding of a relatively uniform bias in the orientation of the adenine–thymine complementary base-pair in human deoxyribonucleic acid.

KB cells[1] were cultured in the presence of 5-bromodeoxyuridine together with 5-fluorodeoxyuridine and uridine for 48 hr. at 36° C. Under these conditions a fraction of the cells undergo a single replication-cycle of their deoxyribonucleic acid[2]. Since 5-fluorodeoxyuridine blocks the endogenous synthesis of the deoxyribonucleic acid thymine precursor, thymidylic acid[3], all the newly synthesized deoxyribonucleic acid strands contained 5-bromouracil in the place of thymine. The cæsium chloride density gradient analysis[4] of the deoxyribonucleic acid from these cells revealed two bands of the acid (Fig. 1). The less-dense band (modal density = 1·702 gm.cm.$^{-3}$) consists of unreplicated deoxyribonucleic acid molecules (that is, 'parental' acid). The more dense bimodal band (inter-modal density = 1·758 gm.cm.$^{-3}$) comprises those molecules of deoxyribonucleic acid which have engaged in one cycle of replication in the presence of 5-bromodeoxyuridine, and thus contain density-increasing 5-bromouracil instead of thymine in their newly synthesized strands. They are 'hybrid' molecules with respect to their 5-bromouracil content. It is proposed that the bimodality of the hybrid deoxyribonucleic acid band arises from a uniform bias in the orientation of the adenine–thymine complementary base pair in most of, if not all, the deoxyribonucleic acid molecules in the cell complement.

By scoring the two possible orientations of a particular base-pair as + 1 and − 1, respectively, along a deoxyribonucleic acid molecule, the bias (β) for that base-pair is defined as the absolute value of the mean score for the molecule. Obviously, $0 \leqslant \beta \leqslant 1$.

The 5-bromouracil content of the two hybrid progeny molecules derived from a single replication in 5-fluorodeoxyuridine–5-bromodeoxyuridine of a molecule of deoxyribonucleic acid, will be different when it possesses an adenine–thymine bias greater than zero, providing the replication is semi-conservative[5–7]. Then the two hybrid molecules will have different buoyant densities.

Similarly, the 5-bromouracil hybrid progeny molecules derived from the semi-conservative replication of a population of deoxyribonucleic acid molecules of heterogeneous base composition, but possessing a uniform adenine–thymine bias, will consist of two equal sub-populations differing in their mean 5-bromouracil content and hence differing in their mean buoyant density.

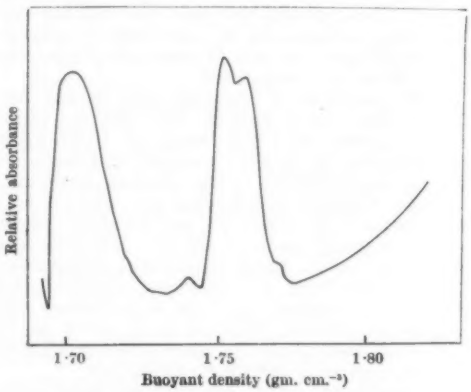

Fig. 1. Spinco 'Analytrol' trace from an ultra-violet absorption photograph of the deoxyribonucleic acid concentration distribution obtained from human *KB* cells. Cells were cultured for 48 hr. in lactalbumin hydrolysate – Earle's saline with 15 per cent heat-inactivated human serum, containing 6×10^{-6} *M* 5-bromodeoxyuridine, 10^{-6} *M* 5-fluorodeoxyuridine and 10^{-5} *M* uridine. Cells were lysed by adding 0·05 ml. of 20 per cent aqueous sodium dodecyl sulphate to 3×10^6 cells in 1 ml. of physiological saline *p*H 8·5 and 0·01 *M* in ethylenediaminetetracetic acid. A 0·5 ml. aliquot of this lysate made up to 57·7 per cent (w/w) with respect to cæsium chloride, and centrifuged at 20° C. for 22·5 hr. at 44,770 r.p.m. The density gradient was 0·122 gm.cm.$^{-3}$.

The mean buoyant density of the parental population (ρ_P) may be written in terms of mean base composition as :

$$\rho_P = \rho_0 + k_1 r_{GC} \text{ gm.cm.}^{-3}$$

where ρ_0 is the intercept at $r_{GC} = 0$, and r_{GC} is the mean molar ratio of guanine–cytosine, and k_1 is the density increment for the total substitution of adenine–thymine by guanine–cytosine.

Similarly, since the substitution of thymine by 5-bromouracil leads to a linear change in buoyant density[4], the mean buoyant density of each population of hybrid progeny molecules (ρ_{H_I} and $\rho_{H_{II}}$) may be written as :

$$\rho_{H_I} = \rho_p + k_2\left(\frac{1+\beta}{2}\right)(1 - r_{GC})\alpha \text{ gm.cm.}^{-3}$$

and:

$$\rho_{H_{II}} = \rho_p + k_2\left(\frac{1-\beta}{2}\right)(1 - r_{GC})\alpha \text{ gm.cm.}^{-3}$$

where k_2 is the density increment for total substitution of thymine by 5-bromouracil, β is the adenine–thymine bias and α the proportion of available thymine sites occupied by 5-bromouracil (here α is assumed to be 1). From the above equations adenine–thymine bias may be evaluated as:

$$\beta = \frac{\rho_{H_I} - \rho_{H_{II}}}{k_2(1 - r_{GC})\alpha}$$

For ease of computation the mode rather than the mean values of buoyant density and guanine–cytosine content were chosen to estimate the adenine–thymine bias of human *KB* cell deoxyribonucleic acid. Substituting 0·184 gm.cm.$^{-3}$ for k_2, 0·39 for r_{GC}, and 0·007 gm.cm.$^{-3}$ for the difference in density between the two modes of the hybrid deoxyribonucleic acid band, one obtains 0·06 as an estimate of the adenine–thymine bias.

In each hybrid sub-population, the uniform incorporation of density-increasing 5-bromouracil is expected to decrease the buoyant density heterogeneity due to variation in guanine–cytosine content. The expected transformation factors (γ_I and γ_{II}) relating guanine–cytosine content to buoyant density for the two hybrid sub-populations (H_I and H_{II}) are respectively:

$$\gamma_I = 1 - \frac{(1+\beta)k_2\alpha}{2k_1}$$

and:

$$\gamma_{II} = 1 - \frac{(1-\beta)k_2\alpha}{2k_1}$$

For this experiment $\gamma_I = 0{\cdot}02$ and $\gamma_{II} = 0{\cdot}14$, using $k_1 = 0{\cdot}100$ as given by Rolfe and Meselson[8].

The variance of buoyant density in the parental deoxyribonucleic acid (σ_p^2) may be written as:

$$\sigma_p^2 = \sigma_T^2 + \sigma_D^2$$

where σ_T^2 is the variance due to thermal motion and σ_D^2 is the variance due to heterogeneity of base composition[10]. Similarly the expected variance of each hybrid sub-population can be written as:

$$\sigma_{H_I}^2 = \sigma_T^2 + \gamma_I^2\sigma_D^2$$

and:

$$\sigma_{H_{II}}^2 = \sigma_T^2 + \gamma_{II}^2\sigma_D^2$$

The expected variance of the hybrid distribution is therefore:

$$\sigma^2[H_I + H_{II}] = \sigma_T^2 + \left(\frac{\gamma_I^2 + \gamma_{II}^2}{2}\right)\sigma_D^2 + \left(\frac{\rho_{H_I} - \rho_{H_{II}}}{2}\right)^2$$

From Fig. 1 it can be clearly seen that the variances of the hybrid sub-population would each be less than the variance of the parental deoxyribonucleic acid band, as one would expect.

The inequality of the modal concentrations of the hybrid deoxyribonucleic acid where the major mode is on the low-density side of the distribution is expected if the less-dense hybrid sub-population (H_{II}) has a γ_{II} value less than γ_I. This would imply a mean γ value less than 0. These expectations do not agree with the calculated values of $\gamma_I = 0{\cdot}02$ and $\gamma_{II} = 0{\cdot}14$. The discrepancy may arise entirely from the gratuitous assumption that the molecular volume is not affected by 5-bromouracil substitution. Indeed, the observed k_2 value (0·184 gm.cm.$^{-3}$) exceeds the k_2 value (0·121 gm.cm.$^{-3}$) expected from the mass increment due to 5-bromouracil substitution, assuming no change in molecular volume. Thus the appropriate k_1 value for computing the γ values may well be less than 0·100 gm.cm.$^{-3}$.

Further studies have been made with the *KB* cell system using aminopterin instead of 5-fluorodeoxyuridine to block endogenous thymidylic acid synthesis[9] and with HeLa cells using the 5-fluorodeoxyuridine-5-bromodeoxyuridine system. Bimodal distributions of the hybrid deoxyribonucleic acid were obtained in each case, confirming the postulate that human deoxyribonucleic acid contains a uniform bias in the orientation of its adenine–thymine base-pairs.

A more detailed account of this work will be published elsewhere.

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CORRELATION OF VIRAL RIBONUCLEIC ACID AND PROTEIN COMPOSITION

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In 1952 Dounce[1] suggested that the sequence of nucleotides in nucleic acid constitutes a code which determines the sequence of amino-acids in proteins. He did not, however, draw any conclusions as to how such a code could be deciphered. In 1954, without knowledge of Dounce's suggestion, Gamow[2] made a similar proposal, and pointed out that information on sequences of amino-acid might make it possible to determine the nature of the code, using elementary cryptographic methods.

About this time considerable information on amino-acid sequences of proteins became available. Numerous efforts were therefore made, mainly by Gamow and his collaborators, to solve the coding problem. These efforts failed[3]. It was found that all proposed solutions were either incompatible with known amino-acid sequences or were not subject to test by evidence then available.

The reason for this failure became clear as information on amino-acid sequences accumulated. Gamow's

original proposal assumed that enough information is available in nucleic acid to determine completely the amino-acid sequence in the corresponding protein. Since there are 20 kinds of amino-acids and only four nucleotides, at least three nucleotides would be needed to specify each amino-acid. As the nucleic acid was visualized to act as a template in protein formation, it was felt that there should not be too great a disparity in length between the nucleic acid and the protein produced. It was therefore assumed that neighbouring configurations of nucleotides, each determining an amino-acid, shared some of their nucleotides, and this, of course, would produce restrictions on possible sequences of amino-acids. 'Decoding' consisted, essentially, of a search for such restrictions, from which the nature of the code could be deduced. Unfortunately, as more amino-acid sequences were published, it was found that there were no restrictions, either absolute or statistical, on which amino-acid could neighbour one another[3]. It was therefore concluded that amino-acid determinants were not configurations of overlapping nucleotides[4]; but no further progress in decoding was possible by the method proposed by Gamow.

These negative results do not necessarily imply that all forms of the coding hypothesis are false, but do suggest the need for developing criteria other than those used by Gamow and his collaborators. It is my purpose to point out that information already available provides evidence on the type of code carried by ribonucleic acid. In what follows, only the 'non-overlapping' types of codes will be discussed.

The most obvious and reliable method of determining the nature of the code would be inspection of sufficiently long sequences of ribonucleic acid and the corresponding protein. The nearest approach to this is provided by the ribonucleic acid viruses, the ribonucleic acid of which apparently codes a single molecular species of protein[5]. As information is available on the approximate compositions of viral proteins and ribonucleic acids the problem is to determine what correlation exists between their compositions, and if such a correlation is found, to deduce the nature of the code. It is possible, of course, that a significant part of the ribonucleic acid has some other, non-coding, function, in which case its composition would bear no necessary relation to viral protein. Demonstration of a correlation would indicate the absence of such a fraction.

To correlate the change in ribonucleic acid associated with change in protein, it is first necessary to define a suitable quantitative measure of the amount of difference between two proteins or ribonucleic acids. This is the molar difference or change Δ_a which is defined as $\frac{1}{2}\ \Sigma|D_a|$, one half the sum of the absolute values of the differences between the quantities, expressed as moles per cent, of corresponding amino-acids in two proteins. The analogous molar difference for ribonucleic acid Δ_n is $\frac{1}{2}\ \Sigma|D_n|$. The reason for choosing these quantities is that they express how many mole fractions of residues in a protein (or ribonucleic acid) have to be replaced by others to obtain a second protein (or ribonucleic acid) of specified composition. Since the unit used is the mole fraction, valid estimates of compositional differences can be made even if the molecular weights are different.

The initial problem is to determine the 'coding ratio' n, or the number of nucleotides required to specify an amino-acid. Since the molar differences between ribonucleic acids or proteins are experimentally determinable quantities, it is useful to consider what relation their ratio Δ_n/Δ_a, which will be referred to as r, bears to the coding ratio n. The nature of this relation can be seen from the following considerations.

Let each amino-acid be determined by n nucleotides. If a protein consists of k residues, the corresponding ribonucleic acid will have nk nucleotides. Each configuration of n nucleotides will then be the same mole fraction of ribonucleic acid as each amino-acid residue is of the protein. If a single amino-acid is replaced by another, the corresponding nucleotide configuration is also replaced, and the molar change in protein will then be the same as the molar change in ribonucleic acid, using nucleotide configurations as a unit. What can be observed, however, are variations in the quantities of individual nucleotides, and the observable molar change in ribonucleic acid will therefore depend on the compositions of the nucleotide configurations which replace each other. For example, a nucleotide configuration Ad-Ad-Ad* could be replaced by Gu-Gu-Gu. In such a case the molar change in ribonucleic acid will be the same as the molar change in protein, $r = 1$. If Ad-Ad-Ad is replaced by Ad-Ad-Gu, $r = 1/3$. A configuration Ad-Gu-Cy could also be replaced by Cy-Gu-Ad, in which case $r = 0$.

Therefore, if one considers a single amino-acid replacement, r can range from 0 to 1; but if the coding hypothesis is correct r cannot exceed 1, and can be 1 only if the amino-acids which replace each other are determined by configurations which have no nucleotides in common. Configurations which have this property will be referred to as 'nucleotide-exclusive' sets. (Examples of such sets would be triplets Ad-Ad-Ad, Gu-Gu-Gu, nucleotide exclusive with respect to Cy-Cy-Cy, Ur-Ur-Ur, or Ad-Ad-Gu with respect to Ur-Cy-Cy.)

The situation is modified if one considers a change in protein involving several different residues. In such a case, r could be 1 only if the configurations in a ribonucleic acid molecule as a group were a nucleotide-exclusive set with respect to the configurations replacing them in the second ribonucleic acid molecule. There is a maximum of four such configurations, so that if five or more amino-acids differ in the two proteins r must be less than 1. This is assuming, of course, that each amino-acid corresponds to a different nucleotide configuration. Usually a random set of configurations would tend to have an overall composition rather similar to most other random sets which would replace them, so that r would tend to be of the order of $1/n$ or less, the exact value depending on the compositions of the nucleotide configurations involved.

It is now possible to consider the experimental evidence, consisting of data on six ribonucleic acid viruses (Table 1). From the foregoing, it will be evident that maximal but not minimal values of r are of interest, and therefore proteins and ribonucleic acids of other viruses are compared to turnip yellow virus, the ribonucleic acid of which differs radically from the others. Molar differences for protein and ribonucleic acid are calculated on this basis.

The ratio of molar difference in ribonucleic acid to molar difference in protein, taking turnip yellow virus as a standard, has the following values: southern bean mosaic virus, 0·90; tomato bushy stunt virus, 0·75; cucumber virus, 0·66; tobacco mosaic virus, 0·83; and poliovirus 1·09. Two of these ratios, for southern bean mosaic virus and poliovirus, are close to 1, the maximum possible if the coding hypothesis

Table 1. Composition in Moles per cent of Viral Ribonucleic Acid and Protein

	SBM(6)	D_a	TBS(7)	D_a	CV(8)	D_a	TMV(5)	D_a	PV(9)	D_a	TY*
ALA	7·7	0·3	8·5	1·1	9·0	1·6	9·2	1·8	7·8	0·4	7·4
ARG	6·4	4·8	5·3	3·7	7·0	5·4	6·7	5·1	4·7	3·1	1·6
ASX	7·3	2·2	11·1	6·0	12·9	7·8	11·6	6·5	11·9	6·8	5·1
CYS	0·9	1·6	0·8	1·7	0·0	2·5	0·6	1·9	0·8	1·7	2·5
GLX	6·8	0·3	5·7	1·4	5·8	1·3	10·4	3·3	7·7	0·6	7·1
GLY	9·0	4·7	8·6	4·3	2·6	1·7	3·7	0·6	6·8	3·1	4·3
HIS	1·3	0·1	1·2	0·2	0·0	1·4	0·0	1·4	2·4	1·0	1·4
ILEU	6·0	2·2	3·3	4·9	4·6	3·6	5·5	2·7	4·8	3·4	8·2
LEU	8·5	0·0	10·9	2·4	9·4	0·9	7·9	0·6	8·5	0·0	8·5
LYS	3·0	3·4	3·4	3·0	2·1	4·3	1·2	5·2	4·7	1·7	6·4
MET	2·6	0·6	0·8	1·2	0·0	2·0	0·0	2·0	1·5	0·5	2·0
PHE	3·4	0·7	3·6	0·9	7·8	5·1	4·8	2·2	4·4	1·7	2·7
PRO	4·7	6·9	3·9	7·7	6·5	5·1	4·8	6·7	7·2	4·4	11·6
SER	9·0	0·7	8·6	0·3	11·7	3·4	11·0	2·7	7·0	1·3	8·3
THR	12·4	1·2	11·0	2·6	7·7	5·9	10·4	3·2	9·1	4·5	13·6
TRY	—	—	0·5	0·2	0·3	0·4	1·2	0·5	—	—	0·7
TYR	4·3	2·8	2·8	1·3	2·7	1·2	2·4	0·9	3·9	2·4	1·5
VAL	6·8	0·6	10·0	2·6	10·0	2·6	8·5	1·1	7·2	0·2	7·4
Δ_a		16·6		22·8		28·1		24·2		18·4	

	RNA (12)	C	RNA (12)	C	RNA (12)	C	RNA†	C	RNA (17)	C	RNA (12)	C
AD	26	28	28	29	26	26	29	28	30	27	23	23
CY	23	24	21	20	19	16	19	17	19	23	38	36
GU	26	25	28	27	26	29	26	27	26	24	17	18
UR	25	24	25	24	30	29	27	28	27	26	22	23
Δ_a	15		17		19		20		20			

D_a—difference in amino-acid composition between protein of specified virus and turnip yellow virus protein. C—Ribonucleic acid composition computed from amino-acid composition. The sums of amino-acids and nucleotides deviate slightly in some cases from 100, due to rounding off of all numbers to two places.

* Mean values from (10) and (11).

† Mean of four determinations (13, 14, 15, 16).

RNA, ribonucleic acid; SBM, southern bean mosaic virus; TBS, tomato bushy stunt virus; CV, cucumber virus; TMV, tobacco mosaic virus; PV, poliovirus; TY, turnip yellow virus.

is correct. If $r = 1$ this implies that all amino-acids differing between two viruses are determined by configurations which are nucleotide-exclusive as between the two ribonucleic acids. Now as the molar difference between the ribonucleic acids of turnip yellow virus and poliovirus and southern bean mosaic virus is due entirely to a large excess of cytidylic acid in turnip yellow virus, and this excess is quantitatively about the same as the molar difference between the proteins, it follows that all, or virtually all, amino-acids which are more abundant in turnip yellow virus protein than in the proteins of southern bean mosaic virus and poliovirus must be determined exclusively by cytidylic acid. At least four amino-acids(*iso*leucine, lysine, proline and threonine) are significantly more abundant in turnip yellow virus than in either southern bean mosaic virus or poliovirus. It would thus appear that more than one amino-acid must be determined by configurations of nucleotides containing only cytidylic acid. This is an unexpected result as it suggests that the coding ratio may be 1, and that viral ribonucleic acid does not carry sufficient information to specify the viral protein completely.

Once a coding ratio of 1 is suggested, there is available a method, quite independent of any of the above arguments, for testing the validity of the proposal, the 'assignment test'. It should be possible to assign to each amino-acid a nucleotide in such a way that the composition of the corresponding ribonucleic acid can be calculated from the composition of the protein. This test is the more stringent as the number of ribonucleic acid-protein pairs increases. Failure to meet this test is, of course, a telling argument against the hypothesis.

The following assignments are suggested: Adenylic acid; glutamic acid, glutamine, glycine, leucine, phenylalanine and tryptophan. Cytidylic acid; cysteine, lysine, methionine, proline, and threonine. Uridylic acid; aspartic acid, asparagine, *iso*leucine, histidine, and serine. Guanylic acid; alanine, arginine, tyrosine, and valine. The sum of amino-acids in each group is the predicted mole fraction of the corresponding nucleotide in the ribonucleic acid, shown in Table 1. In spite of the fact that the compositions of ribonucleic acid and protein of most viruses are only approximately known, concordance of the calculated and experimentally determined abundance of nucleotides in ribonucleic acid is good (Table 1). The Bravais–Pearson coefficient of correlation is 0·92 ($N = 24$), a very significant value. So far as the available evidence goes, the assignment test supports the hypothesis.

In assessing the validity of the proposed amino-acid–nucleotide assignments two sources of possible error should be considered. All the viruses in Table 1, other than turnip yellow virus, are of rather similar composition, and the objection can be raised that the correlation is merely between these viruses as a group and turnip yellow virus, effectively involving only two rather than six independent sets of determinations. That this is not the case, however, is shown by calculating the correlation coefficient without the data from turnip yellow virus, which is 0·87 ($N = 20$) still highly significant. Concordance of the predicted and determined ribonucleic acid composition is therefore still good within this group of similar viruses, although the range of variation is less.

A second, more serious, objection is that from the nature of the case the assignments of amino-acids to nucleotides are selected to give a good correlation, and that the concordance is therefore artificial. This objection is of course quite valid when only one or two cases are considered. But the probability that such a selection will be possible, when no real correlation exists, falls sharply as the number of cases increases. It is indeed a merit of the proposed hypothesis that it can be readily tested by refining analyses and applying them to viruses not yet investigated. So far only the composition of tobacco mosaic virus has been determined with the accuracy modern methods allow.

If the coding ratio of 1 is supported by further data it will be evident that viral ribonucleic acid does not carry all the information required to specify the corresponding protein, and the virus must be considered a joint product of both viral ribonucleic acid and the host. Nothing now known contradicts such a possibility.

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Note added in proof. A recent more extensive redetermination of the composition of poliovirus ribonucleic acid[16] gave Ad, 0·285; Cy, 0·220; Gu, 0·240; Ur, 0·253, which is in much better agreement with the predicted ribonucleic acid composition than the earlier results quoted in Table 1. The coefficient of correlation between predicted and found ribonucleic acid composition for all viruses, using these new data, is 0·95.

*The following abbreviations are used. Ad, Cy, Gu, Ur—adenylic, cytidylic, guanylic and uridylic acids respectively. Amino-acid abbreviations as in ref. 3.

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HÆMOGLOBIN DIFFERENCES IN INBRED STRAINS OF MICE

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THE existence of genetically determined differences in the electrophoretic patterns of hæmoglobin of inbred strains of mice has been reported previously[1,2]. When filter paper[1,2] or starch granules[3] were used as supporting media for zone electrophoretic analyses in veronal buffer *p*H 8·6, two types of hæmoglobin pattern were seen: type 1, also called 'single', was a homogeneous single hæmoglobin, and type 2, also called 'diffuse', contained at least two components, an electrophoretically rapid one with mobility comparable to that of type 1, and a quantitatively smaller electrophoretically slower component. These hæmoglobin patterns appeared to be controlled by a pair of alleles, *Hb*[1] and *Hb*[2]. Of eleven strains of mice tested, three showed the type 1 pattern only, five the type 2 pattern and three strains segregated for both. The hæmoglobin of mice of the F_1 generation, from crosses of type 1 with type 2 resembled, on electrophoresis, the pigment of the type 2 parent. Recently hæmoglobin differences have been demonstrated in different inbred strains of mice with various electrophoretic methods, for example, starch granules[3], starch gels[4] and agar gels[5].

That the relationship between hæmoglobin genes and hæmoglobin types in the mouse was perhaps more complex than assumed originally was suggested by the observation of five different hæmoglobin bands in the work of Rosa *et al.*[4], who used starch-gel electrophoresis. For this reason two observations made in the course of our work on mouse hæmoglobin seemed to require further investigation:

(1) Aqueous solutions of carbonmonoxyhæmoglobin from mice of the *DBA* strain with hæmoglobin type 2 developed a precipitate on prolonged standing at 4° C. whereas no such precipitate developed in hæmoglobin solutions from mice of the Kink strain with hæmoglobin type 1.

(2) Different mice of the *DBA* strain with hæmoglobin type 2 as well as of the F_1 generation from crosses of *DBA* × Kink (resembling hæmoglobin type 2) showed great variability in the amount of the electrophoretically slow component of the diffuse type 2 hæmoglobin.

The present work was an attempt to investigate further these two observations and their possible relationship to the presence of several hæmoglobin bands in certain mice as reported by Rosa *et al.*[4].

Blood was obtained by cardiac puncture of anæsthetized mice, and hæmoglobin was prepared by the method of Drabkin[6]. Oxyhæmoglobin was prepared for solubility studies, and carbonmonoxyhæmoglobin was used for electrophoretic and ultracentrifugal analyses.

The appearance of a precipitate in stored hæmoglobin solutions from *DBA* and F_1 mice and the absence of precipitation in stored Kink hæmoglobin suggested that the two hæmoglobins might differ in solubility. Therefore solubility studies were carried out using a modification of Itano's[7] method. In 3·17 *M* phosphate buffer, and sodium hydrosulphite, Kink hæmoglobin was more soluble (Table 1) than *DBA* hæmoglobin; a value approximately intermediate between these two was obtained for F_1 hæmoglobin.

Starch-gel electrophoresis of carbonmonoxyhæmoglobin was carried out on horizontal and vertical gels

Table 1. Solubility of Hæmoglobin of Inbred Mice in 3·17 *M* Phosphate Buffer, *p*H 7·2

Strain	Amount Hb added* O.D.	Amount Hb soluble O.D.
DBA/1	0·335	0·164
Kink	0·335	0·262

* These values were obtained by recording the optical density of the hæmoglobin in 2·5 molar phosphate buffer and hydrosulphite[7]; no precipitation occurred under these conditions.

according to the methods of Smithies[8,9], within one week after bleeding the animals. This analysis of hæmoglobin of Kink mice (type 1) revealed a single hæmoglobin band. *DBA* (type 2) hæmoglobin included the same and three additional bands, one faster than the main component and two faint slower components. These same three bands, as well as the 'single' band, were visible in F_1 (*DBA* × Kink) hæmoglobin although the electrophoretically slow components were very faint. A semiquantitative method for measuring the relative amounts of hæmoglobin components was based on dissolving a known volume of starch gel with its hæmoglobin in concentrated hydrochloric acid, and the preparation of a blank of the same volume of starch gel in hydrochloric acid without hæmoglobin. Concentrated acid was used, because the presence of excessive amounts of water was associated with turbidity of the resultant solutions. The optical densities of the hydrochloric acid–starch-gel solutions at 400 mμ were obtained on a Bausch and Lomb spectrophotometer. The average amount of slow components in 16 *DBA* animals was 20 per cent and in 40 F_1 animals 4 per cent of the hæmoglobin; no slow component was detectable in Kink hæmoglobin (Table 2). However, when *DBA* and F_1 specimens were stored at 4° C. as either carbonmonoxy- or oxy-hæmoglobin, slow components became apparent in those F_1 specimens in which they were initially lacking, and increased in quantity in other F_1 and in all *DBA* specimens. Hæmoglobin solutions of Kink (type 1) animals stored in identical circumstances failed to accumulate a slow component.

Table 2. ELECTROPHORETICALLY SLOW COMPONENTS OF HÆMOGLOBINS OF INBRED STRAINS OF MICE

Strain	No. of animals	Slow components % of total Hb	Main component % of total Hb
DBA/1	16	5 to 58 (av. 20)	80 (av.)
Kink	10	0	100
F_1	40	0 to 20 (av. 4)	96 (av.)

In order to study the effect of storage on the amount of electrophoretically slow component, pooled hæmoglobin solutions were prepared separately from five *DBA*, from five F_1, and from five Kink animals. Electrophoretic and ultracentrifugal analyses of the hæmoglobin solutions were carried out three days after bleeding and repeated after 28 days of storage at 4° C. (Fig. 1).

Initial starch-gel electrophoresis of the different mouse hæmoglobins gave the picture described before. When the electrophoretic analyses were repeated after 28 days, Kink hæmoglobin appeared unchanged, whereas marked changes were noted in *DBA* and in F_1 (*DBA* × Kink) specimens. Electrophoresis of the *DBA* (type 2) specimen now revealed only two components: (1) the electrophoretically slowest band which had increased markedly in amount, and (2) the electrophoretically most rapid component. Electrophoresis of F_1 (*DBA* × Kink) hæmoglobin after storage revealed changes similar to, but not identical with, those in the parent *DBA* (type 2) hæmoglobin: the electrophoretically slowest component had increased markedly, and a rapid component comparable in electrophoretic migration to the rapidly migrating component of *DBA* hæmoglobin was seen. However, in the stored F_1 hæmoglobin, an electrophoretic component of the same mobility as that of hæmoglobin of the Kink (type 1) parent was still evident.

The initial ultracentrifugal analyses revealed a single peak in Kink and F_1 hæmoglobin in contrast to the *DBA*, which contained in addition a smaller more rapidly moving peak. On ultracentrifugal analysis after the four-week storage period, a small rapidly moving peak appeared in the pattern of the F_1 hæmoglobin which now resembled the initial pattern observed in *DBA* samples, and the height of the rapidly moving peak of *DBA* hæmoglobin increased markedly during this period.

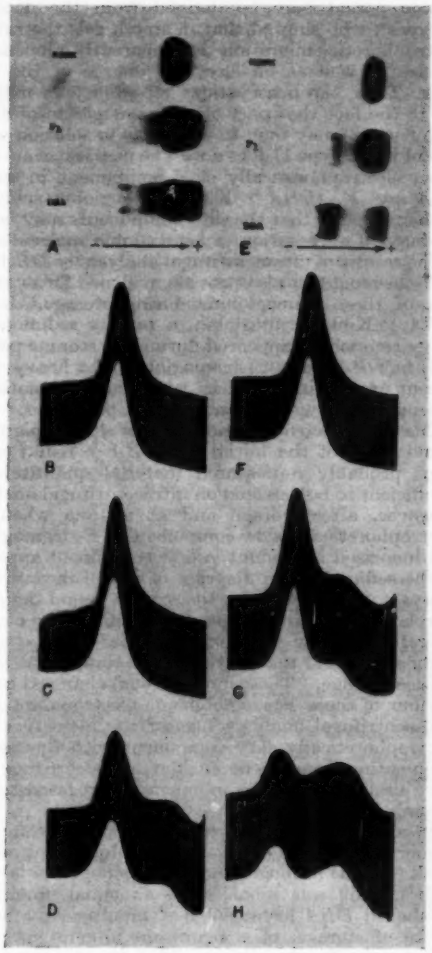

Fig. 1. Electrophoretic and ultracentrifugal analyses of carbonmonoxyhæmoglobin of inbred strains of mice
A, Initial vertical starch-gel electrophoresis[9] of Kink, F_1, and *DBA* hæmoglobins. *E*, electrophoretic analysis of the same solutions after 4 weeks of storage at 4° C. Electrophoretic analyses were carried out for 16 hr. in borate buffer, photographs taken without staining
B, *C*, *D*, initial sedimentation diagrams of Kink, F_1, and *DBA* hæmoglobins respectively
F, *G*, *H*, sedimentation diagrams of same solutions after 4 weeks of storage. Ultracentrifugal analyses were carried out at a concentration of 2 gm. per cent in a 3-mm. cell at 59,780 r.p.m. in a Spinco model *E* analytical ultracentrifuge. Photographs taken in mid-period of each run

The sedimentation constant for the main peak of mouse hæmoglobin was $S_{20} = 4{\cdot}2 \times 10^{-13}$, which is within the range of values given for other animal hæmoglobins by Svedberg and Pedersen[10].

A possible interpretation of the changes in the electrophoretic analysis of type 2 hæmoglobin after a

storage period may be derived from the data of Smithies[8], who showed that in starch gels the rate of electrophoretic migration is apparently dependent on size as well as on electrical charge of the proteins. Thus, the observations reported here may be due to the fact that part of the hæmoglobin of *DBA* mice (type 2) may tend to aggregate in solution while that of Kink (type 1) does not. The increase in amount of an electrophoretically slow component in stored *DBA* and F_1 (*DBA* × Kink) hæmoglobin solutions further suggests that the slow components may be the products of aggregation of hæmoglobin molecules.

The results of ultracentrifugal analyses of *DBA* and of F_1 hæmoglobin also provide evidence for aggregation of these hæmoglobins during storage. In F_1 (*DBA* × Kink) hæmoglobin, a rapidly sedimenting, heavy component appeared during the storage period, and, in *DBA* (type 2) hæmoglobin, the heavy component present in the initial runs increased markedly in amount during the same 28-day period.

The faint electrophoretic bands of slowly migrating hæmoglobin of the initial F_1 (*DBA* × Kink) specimens probably represented material quantitatively insufficient to be detected on ultracentrifugal analysis. However, after storage and at a time when the electrophoretically slow component of F_1 hæmoglobin had increased in amount, a new component appeared in the sedimentation diagram of the ultracentrifugal analys is. Similarly during the storage period there was correlation between increase in amount of the electrophoretically slow component of the *DBA* (type 2) hæmoglobin and that of the heavy component in the ultracentrifuge. The simultaneous changes in behaviour of these hæmoglobins on electrophoretic and ultracentrifugal analyses suggest the identity of the electrophoretically slow component with the rapidly sedimenting component in the ultracentrifuge; we have designated this component 'aggregated hæmoglobin'.

In order to demonstrate that aggregation is a property of *DBA* (type 2) hæmoglobin but not of Kink (type 1) hæmoglobin, Kink hæmoglobin labelled with iron-59 was mixed with an equal amount of unlabelled *DBA* hæmoglobin. The absence, after six weeks of storage, of a significant amount of radioactivity in the slow component suggests: (1) that aggregation is indeed a property of the *DBA* hæmoglobin molecule and not of Kink hæmoglobin, and (2) there is no component of the *DBA* hæmolysate which facilitates aggregation of Kink hæmoglobin.

Large variations in the amount of electrophoretically slow component of different specimens of *DBA* and F_1 (type 2) hæmoglobin are recorded in Table 2. Since the amount of this 'aggregated hæmoglobin' seems to increase with storage time, some of the variation may be explained on the basis of time differences. However, differences in amount of hæmoglobin aggregation during storage may depend on other factors such as the hæmoglobin concentration of the hæmolysate. Whether this slow component exists in the circulating erythrocyte is uncertain: we have repeatedly failed to demonstrate the electrophoretically slowest component when starch gel electrophoresis of *DBA* hæmoglobin was carried out within 2–3 hr. after the animals were killed. In these circumstances, only the three electrophoretically rapid components were observed in the *DBA* hæmoglobin specimen. When electrophoretic analysis of *DBA* hæmoglobin specimen was carried out after storage at 4° C. for several months, somewhat more aggregated hæmoglobin appeared, but the rapid component (Fig. 1) was still present. Further studies of factors affecting the rate of hæmoglobin aggregation are under way in our laboratory.

The appearance of aggregated hæmoglobin in the stored hæmolysate of *DBA* and F_1 (*DBA* × Kink) mice may be related to the spontaneous denaturation of mouse hæmoglobin observed by Rosa *et al.*[4]. The observations on aggregated hæmoglobin in the present report were made on hæmoglobin solutions in which no visible precipitation had occurred. On more prolonged storage, a hæmoglobin precipitate appeared in the *DBA* and F_1 (*DBA* × Kink) hæmolysates: both the supernatant hæmoglobin solution and a solution of the precipitate in veronal buffer *p*H 8·6 were found to exhibit the characteristic spectroscopic absorption bands of carbonmonoxyhæmoglobin. After appropriate treatment of the solutions, the absorption bands of oxyhæmoglobin and of reduced hæmoglobin were readily seen in both.

At least part of the differences between *DBA* (type 2) and F_1 (*DBA* × Kink) hæmoglobin could be explained by the presence of Kink (type 1) hæmoglobin in F_1 mice. The smaller amount of aggregated hæmoglobin in stored F_1 (*DBA* × Kink) hæmolysates may reflect the presence of a smaller amount of *DBA* hæmoglobin in these animals than in the *DBA* parent. Whether this aggregation is a property of the hæmoglobin of all mouse strains which were originally classified in the type 2 hæmoglobin group is uncertain[1,3]; the present work was confined to hæmoglobin of *DBA* and Kink animals and their F_1 offspring.

Our own work[1,2], considered together with that of others[3,4], seems to indicate that the genetic control of mouse hæmoglobin type may be fundamentally analagous to that described for human hæmoglobins in that the phenomenon of co-dominance obtains. The two alleles, Hb^1 and Hb^2, each determine the presence of one particular type of hæmoglobin, that is, 'single' or 'diffuse' and heterozygotes contain a mixture of these two electrophoretically separable hæmoglobin types. The 'diffuse' hæmoglobin type from *DBA* mice determined by the allele Hb^2 contains several components, at least one of which may undergo aggregation. The 'single' hæmoglobin type from Kink mice used in this work, on the other hand, exhibits a homogeneity comparable to that of human hæmoglobin A_1 when subjected to various electrophoretic conditions. Hæmoglobin from F_1 ('single' × 'diffuse') mice representing a mixture of the parent hæmoglobins differs from either parent type, both in quantity and quality of components. It is difficult to carry further the comparison of genetic control of mouse hæmoglobins with that of human hæmoglobins in the absence of further knowledge of the chemical differences between hæmoglobins of type 1 and type 2.

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LETTERS TO THE EDITORS

ASTRONOMY

A New Correlation of the Mayan and Christian Calendars

BECAUSE solar and lunar eclipses and certain other lunar phenomena tend to repeat themselves in a periodic fashion, it has often been stated that it will be impossible to determine the correlation of the Mayan and Christian calendars from astronomical data alone. As a result, the two most generally accepted correlations, the Spinden[1] ($A = 489,384$) and the Goodman–Thompson[2] ($A = 584,283$) depend in part on historical records; A, the Ahau equation, is the Julian Day Number of the zero date of the Mayan calendar. This communication puts forward a correlation which rests on astronomical data and the assumption that the Spinden and Makemson[3] ($A = 489,138$) correlations are within 100 years of the truth, an assumption suggested by early radiocarbon results.

This assumption and a new interpretation of certain pages of the Dresden Codex allow one to proceed to a determination of A with only slight ambiguity. I suggest that the second line on page 24 of the Dresden Codex indicates dates common to a Venus ephemeris and a solar eclipse table, and that the three lines of month names and numbers on pages 46–50 of the Codex, instead of providing three separate ephemerides for Venus, were designed to give dates of solar eclipses preceding and following particular solar eclipses associated with some special dates in the Venus ephemeris.

Let us assume (*a*) that the initial date of the Venus tables, 9–9–9–16–0, 1 Ahau 18 Kayab, as given on page 24 of the Dresden Codex, is also the date of a solar eclipse visible in Central America; (*b*) that the interval from this date to 9–14–2–6–0, 1 Ahau 18 Uo (page 47, Dresden Codex), 33,280 days (line 2, page 24, Dresden Codex), is an interval between two solar eclipse syzygies as well as the interval between two important Venus dates, namely, from a first appearance of Venus as a morning star to a somewhat later disappearance as an evening star; (*c*) that A lies between 489,384 – 36,524 and 489,384 + 36,525, which is equivalent to assuming that 9–9–9–16–0 lies between A.D. April 12, 263, and A.D. April 12, 463, both dates in the Gregorian Calendar. Assumption (*c*) is a re-statement of the one offered in the first paragraph above, namely, that the Spinden correlation is within a hundred years of the truth.

One can now examine the list of solar eclipses in Oppolzer's "Canon Der Finsternisse", looking between A.D. 263 and A.D. 464 for a solar eclipse which was visible in Central America, and which occurred very near a date at which Venus was in inferior conjunction with the Sun. In this interval, there were two solar eclipses meeting this description. The first was an annular eclipse on A.D. December 22, 344, G.C., the second a total eclipse on A.D. December 1, 392, G.C. Equating the former date with 9–9–9–16–0 yields an Ahau equation, $A = 482,699$. The latter date gives $A = 500,210$.

In this brief communication, it does not seem wise to try to give all the reasons for discarding the second value of A; rather it appears more desirable to present some of the reasons for adopting the first, namely, $A = 482,699$.

Consider now the three sets of numerals and month names in the lower part of pages 46–50 of the Dresden Codex. The three initial dates, or 'lubs', are 3 Xul, 18 Kayab, 13 Mac, reading from the bottom up. Let us now examine the six dates:

I. 9–8–3–16–0, 1 Ahau 3 Xul
II. 9–9–9–16–0, 1 Ahau 18 Kayab
III. 9–11–3–2–0, 1 Ahau 13 Mac
IV. 9–12–16–6–0, 1 Ahau 8 Chen
V. 9–14–2–6–0, 1 Ahau 18 Uo
VI. 9–15–15–10–0, 1 Ahau 18 Pax

Using $A = 482,699$, each represents a date within about one day of a solar eclipse syzygy. Venus was 4 days past and 1 day before inferior conjunction with the Sun at (II) and (V) respectively; 286 and 282 days past inferior conjunction and hence near superior conjunction at (III) and (VI); 13 and 14 days before inferior conjunction at (I) and (IV). The consecutive intervals between the dates as listed in order above are: 9,360; 11,960; 11,960; 9,360; and 11,960 days. The interval from (II) to (V) is 33,280 days, one of the numbers on line 2, page 24, of the Dresden Codex. All these intervals are close approximations to intervals between solar eclipse syzygies.

Let us next consider three of the dates given on page 52*a* of the Dresden Codex:

VII. 9–16–4–10–8, 12 Lamat 1 Muan
VIII. 9–16–4–11–3, 1 Akbal 16 Muan
IX. 9–16–4–11–18, 3 Eznab 11 Pax

These dates have often been considered as important items in the interpretation of the lunar tables of the Dresden Codex. The Ahau equation, $A = 482,699$, makes these dates A.D. 477 September 23, October 8 and October 23, G.C. The first date is that of the autumnal equinox, and the third is a solar eclipse syzygy date. The second date is that of a full Moon, one month before a lunar eclipse.

Finally, among the 92 different dates given by Teeple[4], if one omits Nos. 10, 85 and 94, the differences between the age of the Moon, as computed using modern tables (using $A = 482,699$) and as given by the Mayans (in the sense Computed–Mayan), all lie between $+1{\cdot}65$ and $-4{\cdot}25$. There is some evidence that solar eclipses visible in Central America were used to adjust lunar counts; in some cases, corrections of opposite sign were made about the same time in Copan and Piedras Negras, near the time of a solar eclipse visible in those cities.

I wish to acknowledge the generous assistance, particularly in the matter of reprints, of Dr. H. J. Spinden, Dr. M. W. Makemson and Mrs. Howard D.

Day, a niece of Prof. R. W. Willson. I have been fortunate in having an excellent group of students who have tackled the astronomical computing with enthusiasm.

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ASTROPHYSICS

The Possibility of Detecting a Gravitational Red Shift in 21-cm. Radiation from the Galaxy

The interesting suggestion has recently been made by Landovitz and Marshall[1] that a gravitational red shift might be detectable in observations of the 21-cm. hydrogen line from the inner regions of the Galaxy. The effect is proportional to the difference in gravitational potential between the point of emission and the Earth's surface, and so could give independent information on the mass of the Galaxy. Currently accepted values for the mass and scale of the Galaxy would lead to a frequency shift of −3 kc./s. for radiation originating near the galactic centre; this corresponds to a Doppler velocity of +0·7 km./sec.

Landovitz and Marshall point out that this shift would have to be isolated from the much larger Doppler shifts (typically 50–100 km./sec.) arising from the differential rotation of the Galaxy, and suggest methods by which the separation might be made. There are, however, some other effects which appear to have been overlooked by Landovitz and Marshall, and these add considerably to the difficulty of picking out the gravitational effect.

The proposed tests involve a search for asymmetries in the velocity pattern of the 21-cm. radiation over the galactic plane. Rotational effects will be symmetrical about the direction to the galactic centre, but gravitational effects will not. I have recently been concerned with some closely related symmetry questions, through comparisons between our own 21-cm. survey of the southern part of the Milky Way strip[2] and the corresponding Leyden survey for the northern part[3]. Some degree of asymmetry does exist, and in consequence a simple rotation picture cannot give a satisfactory interpretation of the observational results. It seems probable, however, that the asymmetry is related to imperfectly understood motions, rather than to a gravitational shift.

A rotational velocity curve can be derived from 21-cm. observations by the method of Kwee, Muller and Westerhout[4], which they applied to the Leyden data for the northern side of the Sun-centre line. An application of the same method to the southern data is found to give slightly lower velocities. (The reality of this difference between the two velocity curves has also been confirmed by other lines of approach.) The difference of velocity between the southern and northern curves varies with galactic longitude in the way which would be produced by an additional motion of the Sun of about 7 km./sec. outwards from the galactic centre.

In all 21-cm. reductions to date, the observed velocities have been corrected to allow for the so-called 'standard' solar motion relative to the local centre of rest. This value for the solar motion has in effect been determined from the mean motion of stars within 2–3 kiloparsecs of the Sun, and the above result implies that the Sun and the local centre of rest are moving outwards at 7 km./sec. with respect to a larger galactic frame of reference.

Some other considerations suggest that the gas at the Sun's distance from the centre is also streaming outwards with about the same velocity. This motion is presumably connected with the large 'expansion' velocities which have been found in the nuclear region of the Galaxy[5], with the inference that all the gas in the galactic disk is moving outwards, with a velocity which decreases with increase of distance from the centre.

These motions produce substantial asymmetries in the Doppler shifts on the two sides of the direction of the galactic centre, overshadowing the somewhat similar asymmetry which Landovitz and Marshall hoped to use to separate the gravitational and rotational effects. Admittedly, there will be second-order differences in the pattern of the various effects over the galactic disk, but these are likely to be hidden by the random motions and local irregularities.

We should of course consider the possibility that the observed asymmetry, which has been attributed to other causes, might in fact be a gravitational shift. For this to be so, the mass of the Galaxy would need to be increased by 10–20 times from the present estimates, and this seems very unlikely. Furthermore, the variation of the effect over the galactic plane is more in keeping with solar motion as a cause.

The test proposed by Landovitz and Marshall for recognizing the gravitational effect has the further difficulty that the integrated brightness in any direction is weighted heavily in favour of the nearby gas, where the effect is smaller still. One way to concentrate attention on the central region is to consider the small central disk and ring, which have recently been discovered by Rougoor and Oort[6]. These appear to be rotating at nearly 300 km./sec., and a 0·7 km./sec. asymmetry would be difficult to detect. The observed distribution pattern of the radiation in velocity and longitude does show a marked asymmetry, of rather complex form, but it seems more likely that structural factors are responsible for this.

So far we have only considered the potential variation in the galactic plane; but there is also a gradient of gravitational potential in a direction normal to the galactic disk. This would lead to a 'blue shift' in observations towards the galactic poles. A blue shift of a few kilometres per second is in fact observed over most of the high-latitude regions (ref. 7, and unpublished work by R. X. McGee), but it is about two orders of magnitude too large for the potential difference which would be expected over the few hundred parsecs where most of the gas is believed to be.

An observation of the gravitational red shift in our own or an external galaxy would be very valuable; but there seems to be little possibility of recognizing

it, until the detailed structure and motions have been established more definitely.

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RADIOPHYSICS

Identification of Mode in Low-Frequency Sweep Ionospheric Sounding, and Interference Patterns between Overlapping Echoes

To help determine the origin of ionospheric echoes received on low-frequency sweep equipment it is very desirable to know their polarization, but unfortunately such information is not easy to record or display in a convenient manner. However, one of the most important parameters of the polarization is the sense of rotation of the wave vector, and a method has been developed which displays this in a simple way on a normal $h'f$ record.

A conventional pulse transmitter is used, operating over the swept range of 100 kc./s.–1,000 kc./s. The echo is received on a pair of crossed coplanar horizontal dipoles and analysed into its two circular components by means of a two-channel receiver with appropriate phase shifters[1] (see Fig. 1). The resulting video signals are electrically subtracted and applied to the grid of a conventional recording cathode-ray tube with its quiescent brightness adjusted to a level midway between zero and full intensity. Thus any particular echo, which will in general be elliptically polarized, will be displayed either as a light trace or dark trace, depending on its sense of rotation. A linearly polarized echo will not be displayed.

In the examples, a dark trace represents $N \rightarrow E$ (right-handed) polarization and a light trace $N \rightarrow W$ (left-handed); Fig. 2 shows a record in which echoes of both polarizations are clearly visible. The form of this particular record is similar to that described by Watts[2] and the polarization is that which we would expect theoretically if the N_e-levels for all frequencies in the range are at heights greater than the ν_e-level. (The terminology is that of Ratcliffe[3].)

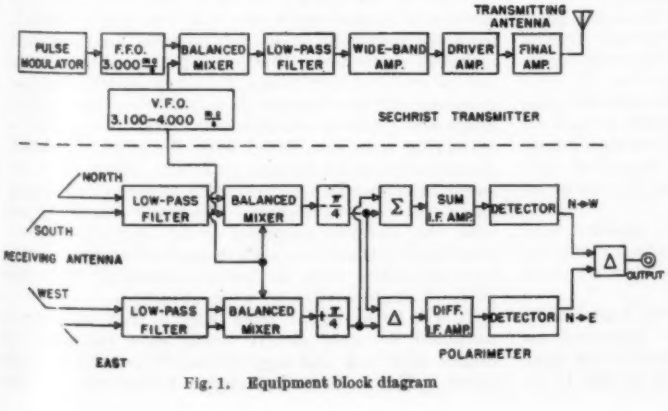

Fig. 1. Equipment block diagram

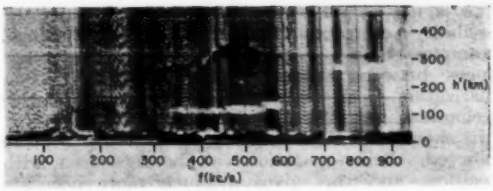

Fig. 2. 0415 January 24, 1960

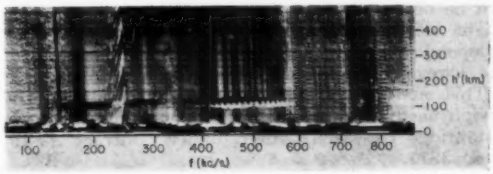

Fig. 3. 0615 March 26, 1960

A particularly interesting effect sometimes observed is the appearance of interference fringes (see Fig. 3). These can be produced if either or both of two overlapping echoes have non-circular polarization, since interference can then take place in either interference fringe channel. Now the fringes are produced as the frequency varies, and hence are a representation of the rate of change (with frequency) of the difference in phase between the two echoes. But, as is well known, the rate of change of phase, φ, with frequency is just equal to the pulse delay of a system, so that in this case it should correspond to the time-interval between the reception of the two echoes. Or, in terms of group height, h', we have:

$$\left(h'_1 - h'_2\right) = \frac{c}{2}\frac{\partial}{\partial\omega}\left(\varphi_1 - \varphi_2\right)$$

There are two possible reasons for the occurrence of a double trace:

(i) If the electron density increases monotonically with height and the gradient is not too great, then ray theory applies, and two magneto-ionic components will be reflected from the layer provided $\nu \ll \nu$ and $\nu \ll \omega$. In this case we expect the upper of the interfering echoes to have $N \rightarrow E$ polarization and the lower to have $N \rightarrow W$. This is just what is observed in Fig. 3. The separation of height of the echo computed from the observed fringe width agrees with that actually observed, namely, 12·5 km. and 12 kc./s.

(ii) If the electron density profile contains sharp gradients, partial reflexions will occur and may give rise to split echoes. In this case, the polarization which the echoes will

have is not at all obvious, but we still have the possibility of production of interference fringe. Examples have been observed of interference fringes between echoes, which, because of their polarization, can only be explained by this mechanism.

It should be noted that whenever fringes are observed, their separation can be measured with precision, and this gives a much more accurate measure of the group-height separation of the echoes than could be obtained by direct measurement of a conventional $h'f$ record. In fact, sometimes fringing can be observed when the existence of a split echo might not otherwise be evident, thus providing independent information about the fine structure of the E-region.

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PHYSICS

Small-Angle Scattering of X-Rays from Deformed Natural Graphite

Examination of deformed metals using techniques of small-angle scattering of X-rays[1], stimulated by the development of theories and experiments on defects in crystals, has been made. Some results obtained along these lines with natural graphite are reported in this communication. In order to obtain deformed graphite it was treated either mechanically or chemically as follows:

(1) *Rolling.* 1 gm. of Ceylon graphite powder was pressed into a copper tube, 5 mm. external diameter and 3 mm. internal diameter, and sealed by turning down both ends. Afterwards the tube was pressed between plates to 4 mm. thick by rolling in a hand mill (5 cm. diameter). The thickness was reduced to 3·35 mm. after 4 passes through the first setting of the roller gap, and it was successively reduced to 2·8 mm., 2·4 mm., and 1·8 mm. by passing through, respectively, the second, third and fourth roller gap. The narrow solid strips of graphite obtained in this manner were carefully dispersed by lightly rubbing in boiling water.

(2) *Extruding.* Graphite powder was pressed into a cylinder, 4 mm. internal diameter, with a load of 200 kgm. The resulting solid graphite rod was introduced into a cylinder of the same diameter and extruded through a nozzle, 1 mm. or 1·5 mm. in diameter, at varying speed.

(3) *Pressing.* 50 mgm. of graphite powder was pressed each time with a piston in a cylinder of hard steel of 4 mm. internal diameter. The ultimate load applied was 3 tons.

(4) *Lamellar compounding.* Lamellar compounds with bromine[2] and potassium[3,4] were prepared as usual since these compounds are reproducible and easy to prepare. It was debrominated at 100° C. in air and at 650° C. *in vacuo*. Potassium was driven off at 400° C. in a sealed glass tube for 12 hr. Then the residue was transferred to a porcelain boat and heated at 800° C. for 1 hr. in an evacuated furnace. Use was made of a slit collimated camera having the sample to the photographic film distance of 28 cm. The determination of the scattering from the different samples was achieved by exposure, under constant operating conditions, on the same photographic film by means of the rotation of the film holder. The sample (100 mgm.) was situated immediately behind the collimating slit uniformly pressed in a holder 2 × 24 mm.[2] and while irradiating oscillated longitudinally with an amplitude of 14 mm. The crystallites in the holder were preferentially oriented so that the layer planes were at right angles to the X-ray beam. Cobalt radiation filtered through Ross-type filters was used.

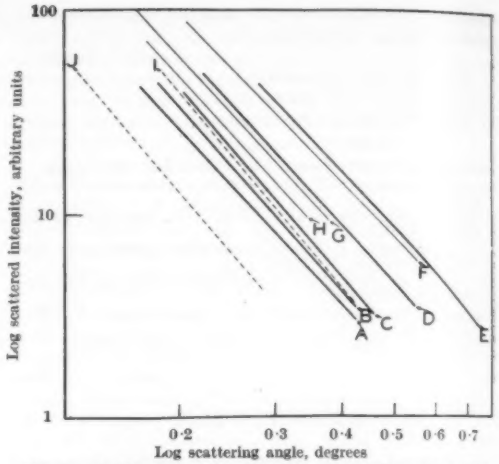

Fig. 1. *A*, Normal Ceylon graphite; *B*, rolled graphite, first stage; *C*, second stage; *D*, third stage; *E*, fourth stage; *F*, extruded through 0·1-mm. nozzle; *G*, pressed at 16,000 atm.; *H*, pressed at 8,000 atm.; *I*, residue of brominated graphite; *J*, residue of potassium compound

The representative scattering curves are plotted in Fig. 1. The intensities of scattering increase with the degree of rolling from curves *A* to *E*. The degree of deformation of the graphite crystal may be expressed with Franklin's p-value[5] and estimated as in my previous work[6] to be, respectively, 0·05, 0·05, 0·055, 0·057 and 0·074. Besides this a slight progressive decrease of the grain-size L was observed and estimated to be, respectively, 827, 804, 741, 647 and 473 Å. from the half-peak width of the 0008 line and using nickel K radiation. For extruded graphite (F) the values are $p = 0{\cdot}055$ and $L = 714$ and for pressed graphite (G) $p = 0{\cdot}053$, $L = 755$. In the case of graphites treated mechanically the intensities of scattering were correlated with the p and L values. Abnormally small intensity (J) was obtained in the case of the sample treated with potassium, whereas p and L values were normal. The result was confirmed with the samples prepared under slightly different conditions. However, with the rolled samples treated and untreated with potassium, identical intensities of small-angle scattering were observed.

It will be apparent from Fig. 1 that the curves obtained are very nearly linear over the range of angles observed and approximately parallel to each other. From this the angle dependence of the

scattered intensity has been found to be $(2\theta)^{-2.5}$, which would correspond to $(2\theta)^{-3.5}$ in the case of pinhole collimated camera. $(2\theta)^{-3}$ dependence was observed by Grosskreutz and Rollins[7] with stressed copper and aluminium in the same range of angles.

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Townsend Ionization Constants in *n*-Alkanes

WE recently measured the first Townsend ionization coefficient, α, in a series of *n*-alkyl chloride gases[1], and found that the dependence of α on molecular structure in these gases was similar to, but different in detail from, that indirectly inferred in the hydrocarbon gases by Devins and Crowe[2] and Heylen and Lewis[3] from measurements of sparking potentials. In order to determine whether these differences are real or are the result of errors in analysis of the results for sparking potentials, we have undertaken the direct measurement of the first Townsend ionization coefficients in the *n*-alkane gases containing 1–6 carbon atoms.

Crowe, Bragg and Devins[4] have, on theoretical grounds, related the ionization coefficient, α, to pressure, p, field, E, and to molecular structure through the relationships:

$$\alpha/p = Af(E/p)\exp(-BP/E) \qquad (1)$$
$$B = k\theta\varepsilon_i^{3/2}$$

A is a constant for a given gas, ε_i is the ionization potential, θ the Ramsauer cross-section, and k, while not necessarily a constant for different gases, was found from measurements of sparking potential to be so for the hydrocarbon gases[2]. The pre-exponential factor $f(E/p)$ in equation (1) was assumed to be equal to E/p for the hydrocarbons[2], although the range of E/p covered with the measurements of sparking potentials was insufficient to distinguish between $f = E/p$ and $f = 1$. Our measurements for the alkyl chlorides[1] showed that equation (1) gave a much better fit for those results if $f = 1$.

The experimental apparatus and procedure have already been described[1]. The gases were more than 99 per cent pure. Pressures were varied from 0·5 to 20 mm. mercury and electrode spacings from 0·2 to 3 cm.

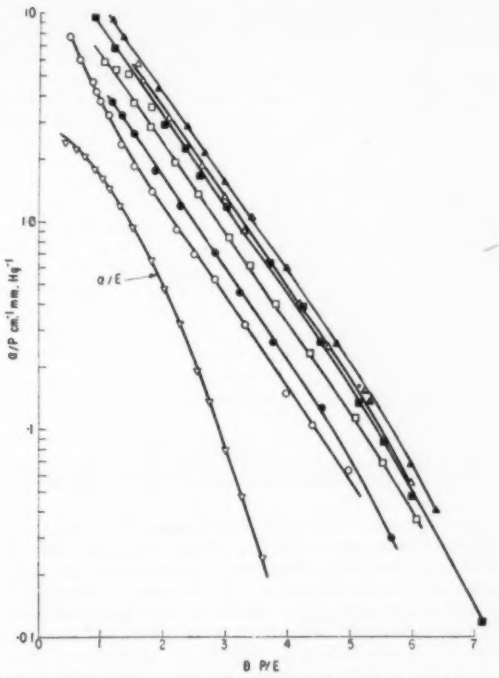

Fig. 1. Dependence of α/p on E/p for the *n*-alkanes: ○, methane; ●, ethane; □, propane; ■, butane; △, pentane; ▲, hexane; ▽, α/E for butane

In Fig. 1 we have plotted our experimentally determined ionization coefficients for the *n*-alkanes containing 1–6 carbon atoms. The abscissa was chosen to separate the individual curves; values of B were obtained from individual plots of log α/p against P/E and are listed in column 3 of Table 1. The curves all show linear regions over a variation in α/p of approximately fifty-fold, with some curvature below $BP/E = 1$ and above $BP/E = 5$. Such deviations are to be expected according to the theory[4]. If $f = E/p$ in equation (1), then the logarithm of α/E should be a linear function of P/E. In Fig. 1 such a plot is shown for butane, arbitrary units being chosen for convenience in plotting. The pronounced curvature suggests that, for the alkanes, as for the alkyl chlorides, equation (1) describes the results better if f is chosen to be unity.

Values of B for the alkanes were re-calculated from sparking potential data[2], assuming $f = 1$ in equation (1). The values, shown in column 4 of Table 1, are 10–25 per cent lower than those obtained in the present work.

Table 1. IONIZATION CONSTANTS IN *n*-ALKANES

Gas	A (cm.$^{-1}$ mm. Hg^{-1})	(*a*) $B(\alpha)$ (V. cm.$^{-1}$ mm. Hg^{-1})	(*b*) $B(V_s)$ (V. cm.$^{-1}$mm. Hg^{-1})	(*c*) $B(V_s)$ (V. cm.$^{-1}$ mm. Hg^{-1})	(*d*) ε_i (eV.)	$\frac{B(\alpha)}{\varepsilon_i^{3/2}}$ (V. cm.$^{-1}$ mm. Hg^{-1} eV.$^{3/2}$)
Methane	8·3	198	181	195	13·04	4·2
Ethane	11·7	226	188	235	11·76	5·6
Propane	17·2	302	235	292	11·21	8·1
Butane	22·5	358	294	336	10·80	10·4
Pentane	24·5	416	336	388	10·55	12·2
Hexane	29·2	476	385	442	10·43	14·1

a, This work; *b*, heavy illumination (ref. 2); *c*, light illumination (ref. 6); *d*, ref. 2.

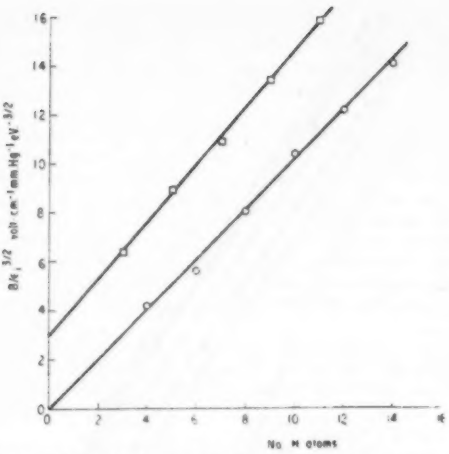

Fig. 2. Relationship between $B/\epsilon_i^{3/2}$ and the number of hydrogen atoms for the normal alkanes, ○, and the normal alkyl chlorides, □

An essential feature of the Townsend mechanism is the independence of the sparking potential on the level of cathode illumination, provided that adequate time is allowed for breakdown to occur. As Heylen and Lewis[3] point out, however, for hydrocarbons, decreases in sparking potential of 10–20 per cent are readily observable on relatively moderate ultraviolet illumination of the cathode. Although with low levels of illumination they observed the same values of B for the alkanes as did Devins and Crowe[2], their values for the alkenes were distinctly lower[5]. In Table 1, column 5, we have included earlier measurements of B of Devins and Crowe[6] made with a 'Pyrex' cell irradiated with a *BH*4 lamp. The effective level of illumination was therefore much lower than in their later work. These values of B agree much more closely with those obtained from measurements of α than do those obtained using a more heavily illuminated gap.

Utilizing our measurements of α, we can calculate from measurements of sparking potentials values for the second Townsend coefficient, γ, assuming the Townsend sparking criterion to be valid. For the relatively heavily illuminated gaps[2], values of γ increase approximately exponentially with decreasing E/p, and lie in the range of 10^{-2}–10^{-1}. With the lightly illuminated gaps of Heylen and Lewis[3] and of Devins and Crowe[5], values of γ are more nearly independent of E/p and much lower (10^{-2}–10^{-3}). These results are consistent with the hypothesis of Heylen and Lewis[3], which suggests that if γ is very low for the hydrocarbons, appreciable distortion of the field by space charge may occur below the Townsend threshold, even with moderate illumination.

Measurements of sparking potentials[2] had indicated that the cross-section θ was a colligative function of the number and types of atoms in a molecule if the contribution of the singly bonded carbon atoms is zero. In Fig. 2 we plot $B/\epsilon_i^{3/2}$, obtained from our direct measurements of α for the n-alkanes and n-alkyl chlorides[1], versus the number of hydrogen atoms. The least-square lines are: for the n-alkane gases, slope $= 1{\cdot}03 \pm 0{\cdot}05$, intercept $= -0{\cdot}1 \pm 0{\cdot}14$; for the n-alkyl chloride gases[1], slope $= 1{\cdot}16 \pm 0{\cdot}03$, intercept $= 2{\cdot}97 \pm 0{\cdot}07$. The zero intercept for the n-alkane curve indicates a zero contribution to θ from the carbon atoms, as was reported earlier[2], and the 12 per cent difference in slope suggests either a slightly different contribution of the hydrogen atom or different values of k for the n-alkane and n-alkyl chloride series.

The constant A for the n-alkane gases appears to be proportional to the number of hydrogen atoms per molecule. An understanding of the dependence of A on molecular structure must await further theoretical work.

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Tungsten-185 in Precipitation and the Seasonal Variations in Fall-out

The introduction of tungsten during the U.S. 'Hardtack' nuclear test series in 1958 provided a unique opportunity of identifying nuclear debris of known origin. From June 1958 until August 1959, tungsten-185 (half-life, 74 days), the tungsten isotope of most interest, was detected in precipitation occurring at Westwood, New Jersey and other stations[1]. Data on both tungsten-185 and strontium-90, and other short-lived isotopes such as barium-140 and strontium-89, in rain-water cast light on the mechanism of stratospheric fall-out, and if suitable corrections for radioactive decay of the short-lived isotopes are made the fraction of debris from 'Hardtack' tests may be estimated. An initial activity ratio tungsten-185/strontium-90 of 500 on July 15, 1958, as suggested by Lockhart *et al.*[2], has been used in this work.

The deposition of tungsten-185 and strontium-90 in precipitation at Westwood, New Jersey, is shown in Fig. 1 together with the rainfall amounts. These curves were constructed by adding the activities in each rain within overlapping 30-day periods, each interval being advanced in 10-day steps. All tungsten-185 results were corrected for radioactive decay to August 15, 1958. Fig. 2 shows a similar graph

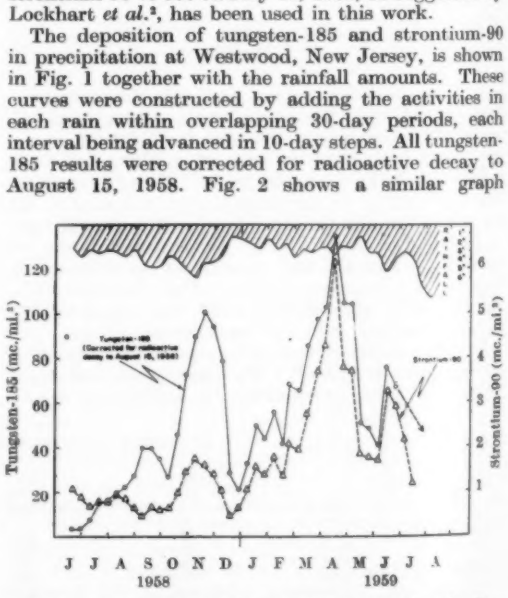
Tungsten-185 (mc./ml.^{3})
Strontium-90 (mc./ml.^{3})
Tungsten-185 (Corrected for radioactive decay to August 15, 1958)
Strontium-90
J J A S O N D J F M A M J J A
1958
1959

Fig. 1. Levels of tungsten-185 and strontium-90 deposition in precipitation at Westwood, New Jersey, during the period June 1958–July 1959

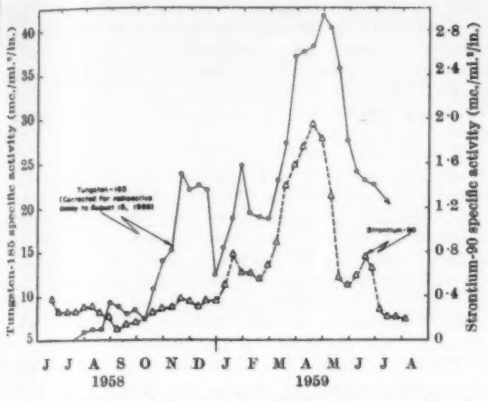
Tungsten-185 specific activity (mc./ml.^{2}/in.)
Strontium-90 specific activity (mc./ml.^{2}/in.)
Tungsten-185 (Corrected for radioactive decay to August 15, 1959)
Strontium-90
J J A S O N D J F M A M J J A
1958
1959

Fig. 2. Variations of the specific activities of tungsten-185 and strontium-90 in precipitation at Westwood, New Jersey

of the variation in specific activity of strontium-90 and tungsten-185 in rains for the period June 1958–July 1959.

It is clear that the deposition of these nuclides varies considerably during the period chosen for discussion. Furthermore, these variations are not due to differences in rainfall amounts as can be seen from the precipitation data in Fig. 1 and the specific activity results in Fig. 2. Perhaps two major peaks in tungsten deposition can be seen, one in November–December 1958, and a second in the spring of 1959. The latter is accompanied by a similar increase in deposition and specific activity of strontium-90, but with the former peak the increased strontium-90 deposition is not so pronounced. The abrupt rises in tungsten-185 and strontium-90 specific activities, commencing in early 1959 and attaining their peaks in mid-April, provide good evidence for the seasonal variation in fall-out first observed by Stewart *et al.*[3]. However, the tungsten curve supports the theory that this spring rise in fall-out is not wholly attributable to the Soviet testing schedule, as postulated by Martell[4], but is rather a meteorological phenomenon and is independent of the geographical origin of the debris[5,6]. The continuous deposition of tungsten-185 during the late autumn of 1958, two to three months after the last

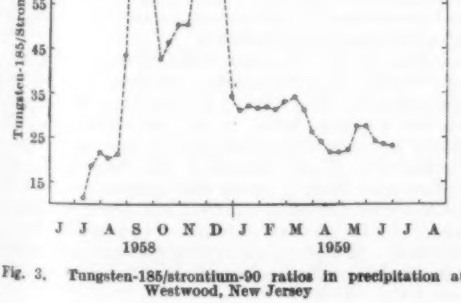

Fig. 3. Tungsten-185/strontium-90 ratios in precipitation at Westwood, New Jersey

major 'Hardtack' tests, is unlikely to be tropospheric debris and we must therefore attribute it to delayed stratospheric fall-out.

Fig. 3 shows the change in the tungsten-185/strontium-90 ratio with time. During early 1959 this ratio remained relatively constant over a six-month period. This indicates that the 'Hardtack' and other debris in precipitation were quite well mixed, and calculations, using the tungsten-185 results to obtain the accompanying 'Hardtack' strontium-90, reveal that only about 8 per cent of the strontium-90 was 'Hardtack' in origin. During earlier periods, that is, in late 1958, this contribution rose as high as 20 per cent. These findings are in good agreement with the conclusions of Lockhart *et al.*[3] from ground-level air measurements. Considerable changes in the tungsten-185/strontium-90 ratio occurred, however, during 1958, probably due to the Soviet testing at that time. Other isotope data (for example, strontium-89/strontium-90 ratios) obtained at this laboratory[7] indicate that 70–80 per cent of the debris sampled during spring 1959 could be attributed to Soviet tests in the autumn of 1958.

The tungsten-185 data have demonstrated, therefore, that material injected into the stratosphere in the equatorial regions is involved in the seasonal variations of fall-out. The spring peaks in fall-out are therefore not entirely a result of the testing schedule nor are they entirely related to the area where detonations have occurred. Furthermore, it appears that the 'residence times' of material injected into the equatorial stratosphere can be relatively short, as discussed recently by Feely[8].

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Elimination of a Glow Discharge in an Induction-heated Vacuum Furnace

WHEN metals and other conductors are heated by induction at low gas pressures, difficulty is sometimes experienced due to electrical breakdown of the gas by the high-frequency electromagnetic field of the induction coil. The effect is most pronounced in the pressure-range, 0·01–0·5 mm. mercury[1]. Occasionally the discharge becomes so intense that effective heating by the work-coil can no longer be obtained, particularly if high temperatures are required.

There has been little reported in the literature on the quenching of high-frequency discharges. McDonald *et al.*[2] found that by using traps cooled in liquid nitrogen to remove mercury vapour, the

discharge could be eliminated. Tokube *et al.*[3] also found this to be effective. Bach *et al.*[4] used a step-down transformer to reduce the voltage across the work-coil from 1,000 V. to 100 V. and found that this entirely eliminated the discharge.

The problem of eliminating such discharges was encountered in this Laboratory in the application of the isotope dilution method to the determination of gases in metals[5]. The technique involved the heating of a graphite crucible approximately 1 in. in diameter by 1 in. in length suspended by platinum wires in a vertical cooled tube 2 in. in diameter, in an atmosphere of carbon monoxide in the pressure-range 0·05–0·5 mm. mercury. Work coils 3 in. in diameter, with 5–10 turns of ¼-in. copper tubing, were used in conjunction with an electronic generator of maximum output of 10 kV. amp. at a nominal frequency of 350 kc./sec. In earlier work[5] in which a 2·5-kV. amp. generator was used and for which better coupling between coil and crucible was obtained, only a faint discharge was occasionally encountered.

In view of the scarcity of data, an outline of several approaches to the problem which have been made in this Laboratory may be of help to present and future users of induction-heated vacuum furnaces.

(*a*) *Gas pressure.* As a result of limitations on the weights of steel samples which can be used in this apparatus, the partial pressure of $C^{16}O$ and $C^{18}O$ is restricted to 0·05–0·5 mm. mercury. An attempt was made to quench the discharge by increasing the total pressure by adding an inert gas. Argon (I. potential 15·7 V.) and helium (I. potential 24·46 V.) were used at pressures up to 20–30 mm. mercury. In both cases an improvement was obtained at low power output; but at the power output which would be used during an isotope dilution run a strong discharge was still obtained.

(*b*) *Mercury Vapour Traps.* The furnace was isolated from any mercury vapour in the system by the use of solid carbon dioxide–acetone traps. Unlike other workers, McDonald and Tokube (*loc. cit.*), I did not find that this was significantly effective in quenching the discharge.

(*c*) *Use of Short Generator-Coil Leads.* The initial experiments were performed with the generator remote from the coil. Because of the possibility of poor grounding due to the long leads, the generator was placed as close as possible to the work coil. A massive earth connexion was also made between the generator and work coil. This assembly gave much better coupling and removed the discharge at low currents. However, it had no significant effect on the discharge at higher power output.

(*d*) *Grounding.* It was observed that there was a certain amount of grounding of the discharge through the clamps supporting the furnace. This produced dark spots on the glassware at these points, probably due to deposition of carbon and platinum particles carried by the ionized gas from the graphite crucible and supporting wires. Following this observation, attempts were made to ground the discharge by grounded wires dipping into the furnace cooling water, without any success.

(*e*) *Use of a Metallic Film.* During the course of the grounding experiments, it was discovered that the discharge was reduced most effectively by hanging unconnected copper wires in the furnace cooling water. The discharge was progressively decreased by increasing the number of wires. Thomson[6] has suggested that the rapidly oscillating electric field is required to initiate a high-frequency discharge and this was confirmed by later workers[7]. It seems likely, therefore, that the successful use of free-hanging wires to quench the discharge may be due to a shielding of the electric field, so that the field strength is reduced below that necessary to produce electrons, by being spread over a greater area of the furnace tube.

The effect of increasing the conductivity of the cooling water was then examined, since from the above argument this should also eliminate or decrease the discharge. It was found that very low concentrations ($<10^{-3}$ *M*) of strong electrolytes, such as sodium chloride, hydrochloric acid, or nitric acid, completely eliminated the discharge. Large pieces of very insoluble substances suspended in the cooling water (calcium fluoride, barium sulphate, silver chloride) had no effect on the discharge.

The final solution to the problem has been obtained by silver-plating, in strips, the inner wall of the furnace water-cooling jacket. When this has been done, no discharge is observed, even at maximum power output from the generator.

In conclusion I would like to acknowledge my thanks to members of the High-Temperature Group of this Laboratory and to Prof. A. D. McDonald of Dalhousie University for helpful discussion of this problem.

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CRYSTALLOGRAPHY

A New Case of Crystallographic Stacking Fault: U_3O_{8-x}

By the use of modern electron optical techniques, the study of structures involving periodic stacking faults (or 'out-of-steps' between 'anti-phase domains') is making remarkable advances. Some of the most recent reports are referred to refs. 1–5. However, many contributions to this field have hitherto been confined mainly to physically ordered states of binary alloys. Now, in the course of electron diffraction investigation of uranium compounds, I have encountered a new case of fault structure which is connected with a chemical decomposition.

In Fig. 1 the electron diffraction pattern of a single crystal of orthorhombic uranium oxide (U_3O_8) is reproduced. The sample is very thin along [001], and the incident beam is in this direction. The pattern is compatible with the crystal structure of orthorhombic U_3O_8 proposed by Andresen[6], and Chodura and Malý[7]. Since the uranium ions in the crystal are all arranged on (001) in a nearly hexagonal manner[6,7], the pattern exhibits a hexagonal feature as a whole. Moreover, the crystal consists presumably of inevitable twins, oriented at 60° to each other around the *c*-axis.

Fig. 1. Electron diffraction pattern of a single crystal of U_3O_8

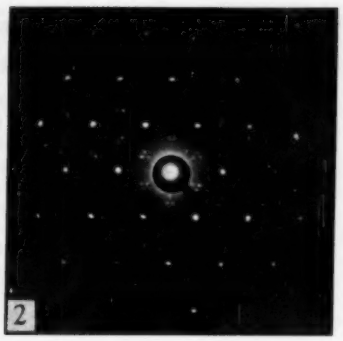

Fig. 2. Electron diffraction pattern of the sample of Fig. 1 after being heated *in vacuo*

When such a single crystal of U_3O_8 is heated *in situ* in the electron optical apparatus, it is reduced eventually to uranium dioxide (fluorite-type cubic) in a special orientation. However, prior to the appearance of the uranium dioxide phase the comparatively weaker spots of Fig. 1 suffer an anomalous splitting as shown in Fig. 2. The splitting becomes more pronounced as the reduction proceeds, while the comparatively stronger spots of Fig. 1 remain almost unchanged. Thus, it seems that before conversion of the orthorhombic lattice of U_3O_8 to the cubic lattice of UO_2 the former undergoes a modification. The chemical formula for the modified stages should be U_3O_{8-x}, where x is a small positive variable.

In Fig. 3*a* the line-up of U^{6+}- and U^{5+}-planes in orthorhombic U_3O_8 with respect to the *b*-direction is depicted schematically. It is to be noted that actually the U^{5+}-planes trisect only approximately the spacing between adjacent U^{6+}-planes. Now, suppose that a particular mode of valency conversions of uranium ions (U^{6+} to U^{5+} or U^{4+}, and U^{5+} to U^{6+}) takes place so as to lead to the sequence, for example, of Fig. 3*b*. Suppose, moreover, that the spacings between adjacent U^{6+}-planes in Fig. 3*b* be either 1 or 4/3 (taking the spacing in Fig. 3*a* as the unit), owing to slight changes in position of uranium ions accompanying the valency conversions. This is an out-of-step structure, where stacking fault takes place at every M-th step of the U^{6+}-plane. For Fig. 3*b* M is 3. It will be readily understood that M decreases as the reduction proceeds, since smaller M means lower density of the U^{6+}-plane in the crystal (Fig. 3*c* and *d*). The asymmetric splitting of spots in the direction above–below in the patterns, such as Fig. 2, can be accounted for by such stacking fault structures, the amount of splitting depending on the value of M. That the split spots in Fig. 2 show an elongation is presumably due to the fact that the M values in the crystal fluctuate considerably around a predominant value. By introducing to the above a triad operation, corresponding to the presence of the 60° twinning, all the anomalous spots of Fig. 2 can be accounted for. The reduction of U_3O_8 to U_3O_{8-x} in this way is supposed to proceed until M decreases to unity (Fig. 3*d*).

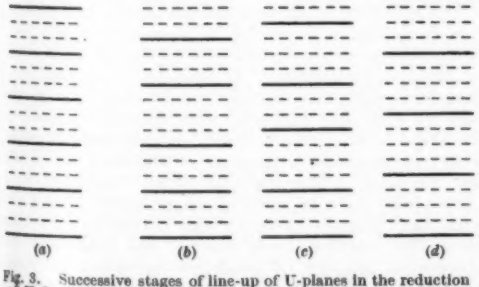

Fig. 3. Successive stages of line-up of U-planes in the reduction of U_3O_8 to U_3O_{8-x}. Solid lines indicate U^{6+}-planes, and broken lines U^{5+}-(or U^{4+}-) planes. (*a*) corresponds to U_3O_8 (Fig. 1). The M values are ∞, 3, 2 and 1 from left to right

A detailed account of this work will be given elsewhere.

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MINERALOGY

Formation of Hydrogarnet by Chemical Reaction among Calcium Carbonate, Ammonium Chloride and some Silicates

THE Lawrence Smith method, which is well known as a procedure for the chemical analysis of alkali ions, has not been considered in the light of structural chemistry. Here we are considering the chemical reaction from the structural chemistry point of view and show that hydrogarnet is frequently formed, which suggests that the reaction should await further studies in relation to the natural skarnization.

As starting materials, we used specimens of feldspars (orthoclase, adularia, microcline, and sanidine) which are free from impurities other than feldspars. The known mixture of $KAlSi_3O_8/CaCO_3/NH_4Cl$ in the ratio (by weight) of 2 : 3 : 2 was heated at the temperatures 100° C., 200° C. . . . 800° C. for 1 hr., immediately cooled, and then washed about ten times with hot water to remove water-soluble salts. The residue was dried at room temperature and analysed by X-ray (Table 1) and chemically (Table 2).

Feldspar and calcite structures are persistent up to nearly 600° C. Wollastonite structure begins to be formed from about 500° C., and garnet structure begins to be formed from about 700° C. The spacing of this garnet structure deviates slightly from that of grossularite. Owing to this fact, coupled with a considerable amount of ignition loss as revealed in the

Table 1. X-ray Powder Data for the Residue obtained from Orthoclase heated at 600° C. (Copper $K\alpha$: 1·5418 Å.)

d (Å.)	I			d (Å.)	I		
7·69	7	W		2·442	18		G (422)
4·90	8			2·340	15	W	G (431)
4·29	5	W	G (220)	2·304	9		
3·83	14	W		2·186	13	W	G (521)
3·58	6			2·058	5		
3·52	17	W		2·023	5	W	
3·39	5			1·981	5	W	
3·31	24	W		1·941	7		G (611–532)
3·23	10	W		1·918	5	W	
3·20	8	W		1·881	4	W	G (620)
3·09	17	W		1·852	6	W	
3·04	11	W		1·834	6	W	
2·988	39	W	G (400)	1·762	6	W	
2·984	6			1·725	7	W	
2·805	5			1·687	4		
2·730	9	W		1·658	9		G
2·675	50		G (420)	1·629	3		G
2·550	10	W	G (332)	1·598	10	W	
2·481	9	W					

W, wollastonite; G, reflexions corresponding to those of grossularite. Numerals in brackets mean indices of reflexions.

Table 2. Chemical Composition of the Residue obtained from Sanidine heated at 650° C.

	Per cent
Silica	35·30
Alumina	12·33
Calcium oxide	43·27
Ignition loss (> 105° C.)	7·20
Water (−)	1·23
Total	99·33

chemical composition, it can be anticipated the garnet may belong to hydrogrossularite.

Earlier papers[1] indicated that the a_0-parameter gradually increases through increasing amount of hydrogen replacing silicon in the grossularite–hydrogrossularite series.

In the present case, the spacing of the garnet structure has nearly a fixed value even in the specimen not having been with hot water. Hence, it can be considered that the hydrogrossularite structure has been formed in the chemical reaction and has nearly a fixed chemical composition. The a_0-parameter was obtained as 11·9$_7$ Å., which is near to that of plazolite:

$$3CaO.Al_2O_3.2SiO_2.2H_2O = Ca_3Al_2(Si_2H_4)O_{12}$$

From the above data, the chemical compositions can be represented as:

$$3\,CaO.Al_2O_3.1{\cdot}5\,SiO_2.3{\cdot}3\,H_2O + 3{\cdot}4(CaO.SiO_2)$$

and the amount of wollastonite obtained from this formula was about 47 per cent, which agrees with that obtained in the natural standard wollastonite specimen.

Heating the known mixture of leuchtenbergite/calcium carbonate/ammonium chloride in weight ratio of 1 : 1 : 1, we were able to obtain periclase and hydrogrossularite structures. Leuchtenbergite and calcite are persistent up to about 700° C., and periclase and garnet structures begin to be formed at about 600° C. The a_0-parameter was obtained as 12·10 Å.

Table 3. Chemical Composition of the Residue obtained from Leuchtenbergite heated at 800° C.

	Per cent
Silica	24·37
Alumina	17·32
Titanium dioxide	0·05
Ferric oxide	0·98
Ferrous oxide	0·24
Magnesium oxide	21·66
Calcium oxide	29·22
Sodium monoxide	0·35
Potassium monoxide	0·19
Water (+)	5·77
Water (−)	0·13
Phosphorus pentoxide	0·16
Manganous oxide	0·06
Total	100·50

The chemical composition (Table 3) can be represented by the following formula:

$$3{\cdot}0CaO.Al_2O_3.2{\cdot}4SiO_2.1{\cdot}9\,H_2O + 3{\cdot}2\,MgO$$

These results may indicate that hydrogarnet can be formed even in a normal atmosphere at about 700° C. or above it, and ammonium chloride may play an important part in its formation. Probably, chlorine acts on calcium ions forming calcium chloride, which reacts on silicates, exchanging potassium ions with calcium ions, and the residue transformed into the following materials as wollastonite, garnet, and periclase. Hydrogen released from ammonium chloride may play an important part in the formation of grossularite.

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RADIATION CHEMISTRY

Reactions of Nitric Oxide or of Oxygen with Benzene Selectively Excited to the Triplet State

We have recently described[1] a method of studying the reactivity of aromatic molecules in their lowest triplet states. For example, the system benzene + nitric oxide, irradiated within the paramagnetically induced[2] forbidden $T \leftarrow S_0$ band (λ2900–3400 Å.), reacts, the photochemically active radiation being absorbed neither by nitric oxide nor by benzene alone. The effect is considered as the reaction of benzene, excited to the lowest triplet state, with nitric oxide in its ground-state.

The products of reaction were removed from benzene solution by extraction with 0·1 *M* aqueous sodium hydroxide and identified by chromato-polarographic separation[3], examination of absorption spectra and polarographic curves, as *o*-nitrophenol and 2,4-dinitrophenol. Hence our previous assumption[1] about the formation of an *iso*nitroso compound was not confirmed. Using the ferrioxalate actinometer[4], we have measured the quantum yield of formation of 2,4-dinitrophenol in monochromatic light of $\lambda = 3130$ Å., finding $\Phi \approx 0{\cdot}012$. *o*-Nitrophenol is formed simultaneously with comparable efficiency.

The influence of nitric oxide on ultra-violet absorption of benzene is similar to that of oxygen, both being due to paramagnetic properties of nitric oxide or oxygen molecules. It seemed very probable, therefore, that this analogy would also exist in the case of chemical reaction with benzene excited to the triplet state. Pure dried benzene was saturated with oxygen under a pressure of 100 atm. to favour the reaction. The samples were irradiated with ultra-violet light of spectral range λ2900–3600 Å., or with the isolated mercury line λ3130 Å. In both cases the reaction took place. We examined the absorption spectra of products extracted in water or 0·01 *M* sodium hydroxide solution. The absorption maximum observed in alkaline solution at

285 mμ is similar to that of the phenolate anion. This spectrum reveals also the existence of a second product, probably *o*-benzoquinone. This assumption is supported by the absorption spectrum of neutral aqueous solutions in which a distinct maximum at 277 mμ was observed and by a weak positive reaction with 2,4-dinitrophenylhydrazine. The quantum yield of formation of phenol determined with the ferrioxalate actinometer is $\Phi \approx 0{\cdot}03$. The small values of the quantum yields of both reactions may be ascribed to the low stability of the primary addition products.

Recently, Loeff and Stein[5] irradiated benzene in aqueous buffered solutions and identified phenol and mucondialdehyde as reaction products. They assumed the addition of the hydroxyl radical to the unexcited benzene molecule; alternatively they mentioned the possibility of reaction of the oxygen molecule with an excited hydrocarbon molecule. However, they gave no further details.

In our experiments, the reaction investigated seems to be unambiguously that of benzene excited to the bi-radical triplet state with an oxygen molecule in the ground-state.

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Examination of γ-irradiated Benzene for Optical Activity

In a recent communication, Starodubtsev, Gurskiy and Sizykh[1] studied optical effects in benzene resulting from its irradiation with γ-rays from a cobalt-60 source with a flux of 3×10^5 r./hr. They report in one short paragraph, which is here directly translated: "Interesting is the fact of rotation of the plane of polarization. Although the rotation is not large (0·7–0·9° at a dosage of 10^7 r. and sample thickness of 10 cm.) it nevertheless indicates the occurrence of asymmetric molecules not possessing a centre or a plane of symmetry".

This observation is potentially of great theoretical significance in that it suggests asymmetric synthesis from a symmetrical chemical reagent and, presumably, symmetrical photons. This could have a bearing on the origin of life as we know it, which is based on asymmetric molecules, and in many other fields. However, since the quoted report runs counter to currently accepted concepts of asymmetric induction and related reaction mechanisms, it was considered important to check the validity and reproducibility of the phenomenon.

For this purpose, specially purified benzene was prepared by taking reagent-grade thiophene-free benzene and subjecting it first to extraction with concentrated sulphuric acid until the washings were colourless, then washing with aqueous sodium carbonate and water, drying over potassium carbonate, fractional distillation from sodium and retaining the middle third cut, two fractional crystallizations and, finally, redistillation from potassium. This product, boiled sharply at 80·5° (uncorr.) at 748 mm., n_D^{25} 1·4981, n_D^{20} 1·5009 ± 0·0001 (compared to n_D^{20} 1·5011 ± 0·0001 reported by Starodubtsev *et al.*[1]). In a polarimeter cell of 40 cm. path length the observed rotation was 0·000° ± 0·002° at 25° for the sodium-*D* line as read on a Rudolph Hi-Precision model 80 polarimeter.

The purified benzene was carefully degassed by alternate freeze-pump-melt cycles and trap-to-trap distillation on a vacuum line. Approximately 30 ml. were distilled into a cylindrical 'Pyrex' ampoule 21 cm. × 2·5 cm. diameter fitted with a break-seal. The sample was sealed under vacuum and irradiated in a 20,000-c. cobalt-60 source of conventional design[2] at a dose-rate of $6{\cdot}0 \times 10^7$ ergs/gm. (c.)/hr.

After irradiation to an integrated dose of $3{\cdot}3 \times 10^7$ r., the sample was removed from the source and again sealed to a vacuum system. The ampoule was opened under vacuum, and an atmosphere of dry helium was admitted to the system. The sample was then opened to the atmosphere and transferred quickly to the proper cells, previously flushed with helium, for examination.

The benzene solution was light yellow in colour and had an unusual not easily describable pungent odour which obscured that of the benzene. In attempts to analyse the solution on a Burrell Kromo-tog gas chromatograph employing an 8-ft. column packed with 'Apiezon *L*' on firebrick, the benzene came off well but the odorous component was retained and could not be removed from the column at room temperature or even at 100°.

The solution after irradiation had a refractive index n_D^{25} 1·4980 ± 0·0001. An ultra-violet absorption difference spectrum was obtained on a Cary model 11*MS* double-beam spectrophotometer with the original purified benzene as the reference solvent. In a 1-cm. cell only four peaks were observed at wave-lengths between the solvent cut-off at 2800 Å. and the instrument limit at 8000 Å. These local maxima and their absorbances (in parentheses) as determined by appropriate dilutions were as follows: 4459 Å. (0·27), 4137 Å. (0·79), 3680 Å. (2·5) and 2767 Å. (38·8).

To check the report of optical activity the irradiated benzene was again examined in the polarimeter in a 40-cm. cell. The observed rotation was 0·000° ± 0·002°, identical with that found for the original unirradiated benzene.

It seems certain, therefore, that although irradiation at the dosage-level described does bring about certain significant effects (colour, spectral change, odour, among others), there is no substantiating evidence from our work that asymmetric genesis of molecules of any optically active material in appreciable amounts has occurred. Since our apparatus was sensitive enough to detect easily 0·005° rotation, this means that for the 40-cm. cell, no effect as great as even 0·2 per cent of that reported by Starodubtsev *et al.* could be found. It seems reasonable, then, to suggest that these workers inadvertently may have had either a contaminated sample or an imperfect polarimeter (in calibration or operation). Their experimental description and apparatus seem simple enough to exclude any unusual irradiation conditions.

We sincerely regret being unable to duplicate the observations of the Soviet workers since the consequences of such validation in the fields of biochemistry, biogenesis, physics, and chemistry would have

been revolutionary and would have revised many of our present concepts of molecular structure, asymmetric induction, electromagnetic interaction, etc.

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CHEMISTRY

Strength of Silica Glass

Griffith[1] extrapolated from his experiments the strength of glass to the order of 1,000 kp./mm.^{2}, which is many times larger than the strength of the best steel. Orowan[2] calculated from mechanical principles a value of the same order. More recent measurements, however, gave a much higher value for several silica-glass fibres, namely, 2,460 kp./mm.^{2} (ref. 3); therefore a calculation based on the atomic structure of glass seems to be important.

Starting from the oxygen ion volume v of glass[4,5], which is in silica glass $22{\cdot}70 \times 10^{-24}$ cm.^{3}, we can calculate the number of oxygen bridges per unit cross-section. The average number of bridging oxygen ions y plus that of the non-bridging oxygen ions x which belong to one silicon ion is 4.

The average number of oxygen ions per net-forming ion (silicon, aluminium, boron, etc.) being R, then:

$$R = \mathrm{O}/(\mathrm{Si} + \mathrm{Al} + \mathrm{B} + \ldots) = x + y/2$$

since the bridging oxygen ion belongs to two net-forming ions at the same time. From the above relations:

$$y/(x + y) = 2 - R/2$$

The plane of the cube containing an oxygen ion being $v^{2/3}$, the number of oxygen ions per cm.^{2} glass cross-section is $1/v^{2/3}$ and that of the bridging oxvgen ions:

$$n = \frac{2 - R/2}{v^{2/3}}$$

The strength of any glass is proportional to n if the glass is really a network of tetrahedra connected with bridging oxygen ions. Silica glass has the smallest R value, 2·00, among all silicate glasses (not containing beryllium, boron, aluminium or other network-forming ions of less than four valencies); therefore it has the highest strength, which is in accordance with the experimental facts.

The distance Si—O in silica is $r = 1{\cdot}60 \times 10^{-8}$ cm. and there is a Coulomb attraction $-8e^2/r^2$ between Si^{4+} and O^{2-}. We calculate after Kossel[6] the work necessary for the separation of an oxygen from the SiO_4 tetrahedron (so that an SiO_3 triangle remains) as the difference of formation energy of an SiO_4 ion $-17{\cdot}32e^2/r$ and that of an SiO_3 group $-17{\cdot}08e/r^2$, that is, $0{\cdot}24e^2/r$ per bridging O^{2-} ion or:

$$\frac{0{\cdot}24(4{\cdot}80 \times 10^{-10}\ \text{e.s.u.})^2}{1{\cdot}60 \times 10^{-8}\ \text{cm.}} = -3{\cdot}456 \times 10^{-12}\ \text{erg.}$$

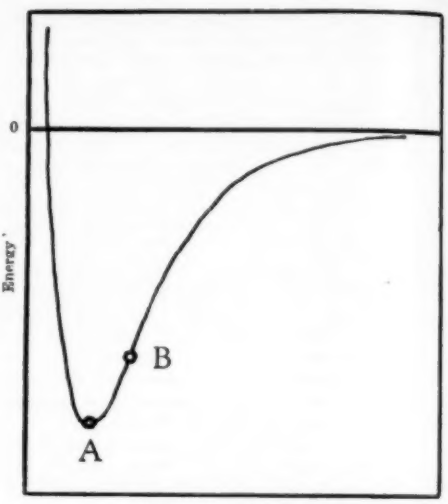

Fig. 1

In the non-periodic network of glass we approximate the potential function of the pseudo-diatomic molecule SiO_3—O by the potential function of a diatomic molecule with the well-known qualitative form of Fig. 1. At the minimum energy (A) there is equilibrium; if a stretching force is applied, the distance grows until the break of the Si—O bond occurs in the point of inflexion (B).

The potential of the pseudo-diatomic molecule SiO_3—O can be taken approximately as the Morse function:

$$U(r - r_e) = D_e\,(1 - e - \beta(r - r_0))^2 \qquad (1)$$

where U denotes the energy, r_e the distance Si—O in the equilibrium, r the actual nuclear distance, D_e the binding energy in the equilibrium and β a constant. Since at the inflexion point $\mathrm{d}^2U/\mathrm{d}r^2 = 0$, we get from (1):

$$2e - \beta(r_i - r_0) = 1 \qquad (2)$$

where r_i is the nuclear distance in the inflexion point. The force there is:

$$F_i = -\frac{\mathrm{d}U}{\mathrm{d}r} = [2\beta D_e\,(1 - e^{-\beta(r - r_e)})e^{-\beta(r - r_e)}]_{r = r_i} \qquad (3)$$

The numerical values in this equation are known: $r_e = 1{\cdot}60 \times 10^{-8}$ cm., $D_e = 0{\cdot}24e^2/1{\cdot}60 \times 10^{-8}$ cm. $= 3{\cdot}456 \times 10^{-12}$ erg $= 1{\cdot}74 \times 10^4$ cm.$^{-1}$ hc.; we need calculate only β. This can be done with the aid of the equation[7]:

$$\beta = 1{\cdot}2177 \times 10^7 \omega_e \sqrt{\mu_A / D_e}$$

Here μ_A, the reduced mass, must be expressed in atomic weight units ($\mu_A = 13{\cdot}22$ in the case of the pseudo-diatomic molecule SiO_3—O) and D_e in cm.$^{-1}$; ω_e is the frequency of the fundamental oscillation. On the basis of the relation[8]:

$$D_e = \frac{\omega_e^2}{4\omega_e x_e}$$

and since the anharmonicity factor of the oscillation found for the $^{28}Si^{16}O$ molecule is $4{\cdot}87 \times 10^{-3}$ (ref. 9) and taking this value as an approximation for our case, ω_e can be calculated as 339 cm.$^{-1}$. With

this the value of β becomes $1 \cdot 138 \times 10^8$. Considering (2) we get :

$$F_i = 2.1 \cdot 138 \times 10^8 . 3 \cdot 456 \times 10^{-12} (1 - 0 \cdot 5) . 0 \cdot 5 = 1 \cdot 97 \times 10^{-4} \text{ dyne}$$

for an Si—O bond in the above sense.

The strength of a silica fibre per cm.² is therefore $1/^{0 \cdot 13}$ times F_i, that is, $1 \cdot 97 \times 10^{-4}$ dyne/$(22 \cdot 7 \times 10^{-24})^{2/3}$ cm.² $= 2 \cdot 42 \times 10^{11}$ dyne cm.$^{-2}$, or 2,472 kp./mm.². This calculated value is closest to the maximum experimental value, 2,460 kp./mm.². Apart from the experimental errors we must consider that our calculation is based entirely on the assumption of Coulomb forces although the bond is partly covalent. It seems, therefore, that the errors due to different approximations in our calculation cancel themselves out.

The strength of asbestos fibres[10] and that of industrial glass fibres, although only of the order of 600–700 kp./mm.², is much higher than the highest strength of thin metal wires, which is about 400 kp./mm.² (for thinnest tungsten wire).

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New Univalent Cobalt Complexes of the $[Co^{I}dg_2X_2]$ Type

Dicyano - *bis* - dimethylglyoximato - cobaltate(III) complex, *trans*-$K[Co^{III}dg_2(CN)_2] \cdot 3/2\, H_2O$ (a new compound)[1] ($dg = H_3C \cdot C(NOH) \cdot C(NO) \cdot CH_3$), was found to be reduced at the dropping mercury electrode in one step to a univalent cobalt complex polarographically in 1 *M* potassium chloride supporting electrolyte. The following electrode process was ascertained.

$$[Co^{III}dg_2(CN)_2]^- + 2e^- \rightleftarrows [Co^{I}dg_2(CN)_2]^{3-}$$
yellow blue

The resulting cobaltate(I) complex, $K_3[Co^{I}dg_2(CN)_2]$, was isolated from the solution as a blue compound in an atmosphere of nitrogen.

The above electrode reaction is quasi-reversible polarographically. The half-wave potential of the cathodic wave did not agree with that of the anodic one.

On the other hand, *bis*-dimethylglyoximato-cobalt(III) complexes,

$$[Codg_2(NH_3)_2]Cl \cdot 5H_2O, \quad [Codg_2(NH_2C_2H_5)_2]Cl, \quad [Codg_2py_2]NO_3 \quad (py = \text{pyridine}),$$

and so on, were found to undertake the stepwise reduction to a zero-valent cobalt complex irreversibly through cobaltate(I) complexes at the dropping-mercury electrode in the same supporting electrolyte. The main processes of the electrode reaction were concluded to be as follows :

$$[Co^{III}dg_2X_2]^+ + e^- \longrightarrow [Co^{II}dg_2X_2] \quad \text{1st wave}$$
$$[Co^{II}dg_2X_2] + e^- \longrightarrow [Co^{I}dg_2X_2]^- \quad \text{2nd wave}$$
$$[Co^{I}dg_2X_2]^- + e^- \longrightarrow [Co^{0}dg_2]^{2-} + 2X \quad \text{3rd wave}$$

where X denotes a neutral unidentate ligand, such as ammine, ethylamine, or pyridine.

On the contrary, as regards the other complexes of the type, $[Co^{III}dg_2X_2]$, the ligand of which, X, is a negative radical or ion, only the first wave was obtained in every case, mainly due to the hindrance of a large maximum wave (Table 1).

The diffusion current and the concentration of the complex are linearly related at the concentration in the range of $10^{-3} - 10^{-4}$ *M* with respect to all the complexes.

I wish to thank Prof. R. Tsuchida for helpful discussions.

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A New Synthetic Route to Alkylphosphonous Dichlorides

IT has recently been shown[1] that electron-donating solvents such as diethyl phthalate (DEP) provide a convenient route to the synthesis of alkylphosphonic dichlorides from the complex formed by combination of an alkyl halide, phosphorus trichloride, and aluminium chloride[2]. It has since been found that alkylphosphonous dichlorides may be synthes-

Table 1. HALF-WAVE POTENTIALS OF DIMETHYLGLYOXIMATO COBALT(III) COMPLEXES (25° C.)

Complex compound	$E_{1/2}$	*n*	Change of valence	$E_{1/2}$	*n*	Change of valence	$E_{1/2}$	*n*	Change of valence
$[Co^{III}dg_2(NH_3)_2]Cl \cdot 5H_2O$	− 0·65	1	$Co^{III} \rightarrow Co^{II}$	− 1·04$_5$	1	$Co^{II} \rightarrow Co^{I}$	− 1·27$_5$	1	$Co^{I} \rightarrow Co^{0}$
$[Codg_2(NH_2C_2H_5)_2]Cl$	− 0·66	1	$Co^{III} \rightarrow Co^{II}$	− 1·08	1	$Co^{II} \rightarrow Co^{I}$	about − 1·25	1	$Co^{I} \rightarrow Co^{0}$
$[Codg_2py_2]NO_3$	about − 0·22*	1	$Co^{III} \rightarrow Co^{II}$	− 0·88	1	$Co^{II} \rightarrow Co^{I}$	− 1·18	1	$Co^{I} \rightarrow Co^{0}$
$K[Co^{III}dg_2(CN)_2] \cdot 3/2H_2O$	− 0·35	1	$Co^{III} \rightarrow Co^{II}$	− 1·10$_7$	2	$Co^{III} \rightarrow Co^{I}$			
$Na[Co^{III}dg_2(NO_2)_2]$	+	1	$Co^{III} \rightarrow Co^{II}$						
$H[Co^{III}dg_2Cl_2]$	− 0·15$_5$	1	$Co^{III} \rightarrow Co^{II}$						
$[Co^{III}dg_2(NO_2)(OH_2)]$									

Supporting electrolyte, 1 *M* potassium chloride; potential unit, volt versus the saturated calomel electrode; concentration of the complex, 0·005 *M*.

* Small maximum wave (in the absence of maximum suppressor).

ized from similar solutions of the complex by reduction with finely powdered antimony. The reaction scheme is:

$$R\mathrm{Cl} + \mathrm{PCl_3} + \mathrm{AlCl_3} \longrightarrow [R\mathrm{PCl_3}]^+[\mathrm{AlCl_4}]^- \overset{\mathrm{DEP}}{\rightleftharpoons} R\mathrm{PCl_4} + [\mathrm{AlCl_3}][\mathrm{DEP}]$$

$$3R\mathrm{PCl_4} + 2\mathrm{Sb} \longrightarrow 3R\mathrm{PCl_2} + 2\mathrm{SbCl_3}$$

The reactions are exothermic and proceed smoothly in a single flask. Yields of $R\mathrm{PCl_2}$ from 90 to 55 per cent have been obtained repeatedly for $R = \mathrm{CH_3}$ to $R = \mathrm{C_5H_{11}}$. Full details of the method and its application in high-activity synthesis of organophosphorus compounds labelled with radioactive phosphorus will be published elsewhere.

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Use of Spectrophotometric Evidence for Protein-Dye Binding

Shifts in the ultra-violet absorption spectra of aqueous organic solutions of some amino-azo dyes on the addition of buffered protein solutions have frequently been interpreted as evidence of complex formation between protein and dye[1-4]. The effect of the buffer itself on the spectrum of the dye has apparently not always been checked, and the fact that this may influence the results is shown by the following experiments.

The powerful carcinogen dimethyl-*p*-aminoazobenzene and its biologically inactive isomer monoethyl-*p*-aminoazobenzene, purified chromatographically on an activated alumina column, were investigated in approximately 10^{-4} molar solutions in 20 per cent dioxane–water mixtures, between 350 and 550 mμ, using a Unicam *SP*500 spectrophotometer. Solutions were thermostatted at 25° C. for 24 hr. to attain equilibrium before measuring the spectra at the same temperature.

The spectra of the azo-dye solutions were determined under the following conditions: (1) With the addition of hydrochloric acid (analytical reagent) to give a range of *p*H 0–5. (2) At *p*H approximately 6 maintained by the use of acetate, phosphate and phthalate buffers, immediately after preparation of the solutions and at intervals of time up to 24 hr. thereafter. (3) In acetate buffered solution at *p*H 6, in the presence of 0·1 per cent gelatin, high grade, edible (Imperial Chemical Industries, Ltd.), and of 0·1 per cent bovine plasma albumin fraction V, and on the addition of 5 ml. of concentrated solution of bovine fibrinogen fraction I, pepsin and trypsin (Armour Biochemicals, Ltd.) per 95 ml. of dye solution. (4) In unbuffered solution in the presence of 0·1 per cent bovine plasma albumin. (5) Before and immediately after shaking for 1 hr. with solid bovine plasma albumin and centrifuging off the solid.

The results of these measurements may be summarized as follows: (1) Plots of extinction coefficient against wave-length for solutions of different *p*H show an isobestic point at 475 mμ for dimethyl-*p*-aminoazobenzene and at 465 mμ for monoethyl-*p*-aminoazobenzene. The peak in the curves for the latter is shifted towards shorter wave-lengths compared with that for the former, which, according to Kubo[2], indicates a lesser ability to release electrons. (2) The spectra of the dye solutions with acetate buffer were unchanged after 24 hr., and those of the dye solutions alone were unchanged after several days, showing that dioxane had not affected the spectra. In the case of the phosphate and phthalate buffers there was a marked and progressive shift with time, up to 24 hr. at least, of the peaks of the curves for both dyes, the changes being most pronounced for solutions of dimethyl-*p*-aminoazobenzene. The shifts are similar to those expected from complex formation, but the nature of any such complex and its slow formation in the present systems seem difficult to explain. The phosphate buffer in addition caused some flattening and lowering of the peaks. This normally indicates the removal of the absorbing compound, although it is impossible to state from the present data the way in which this is occurring here. (3–5) In no case was there any change in the dye spectrum on the addition of protein whether to acetate buffered solutions or to the unbuffered solutions.

The *p*H values of all solutions remained unaltered with time, and observed spectral shifts cannot, therefore, be ascribed to changes in *p*H.

In view of the observed effects of certain buffers on the spectra of the azo-dyes used here, a re-examination of some of the earlier findings seems desirable, together with a more extensive investigation of the effect of these and other buffer solutions on the spectra of such systems.

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BIOCHEMISTRY

Enzymatic Degradation of Deoxyribonucleic Acid into Sub-units

The generally accepted value for the molecular weight of deoxyribonucleic acid is $6–8 \times 10^6$ (refs. 1 and 2). In the course of a study of methods of preparation involving extraction with solutions of low ionic strength, it has been found that, under a given set of experimental conditions, preparations from chicken erythrocytes could be obtained which showed reproducibly lower molecular weights (Champagne, M., unpublished work). This finding is reminiscent of some results scattered in the literature[3] and suggestive of some enzymatic activity involving depolymerization of deoxyribonucleic acid. An investigation was therefore undertaken of the action on deoxyribonucleic acid of preparations from chicken erythrocytes.

Two preparations of deoxyribonucleic acid were mainly used in this work: *B1s* from calf thymus

($M_w = 6{\cdot}5 \times 10^6$; $S^\circ_{20,w.av.} = 20\,S$) and *B*2 from chicken erythrocytes ($M_w = 8{\cdot}0 \times 10^6$; $S^\circ_{20,w.av.} = 27{\cdot}5\,S$). The crude enzymatic preparations were obtained as follows. Erythrocytes separated by centrifuging one volume of chicken blood, to which half a volume of heparinized 0·15 *M* sodium chloride – 0·01 *M* sodium citrate had been added, were lysed with 0·1 per cent saponin in this saline–citrate solvent, then rapidly washed once with distilled water, centrifuged, suspended in distilled water (2·5 vol. per vol. of blood) and shaken overnight in the cold room. The yellowish, viscous, homogeneous suspension was used on the following morning: 1 ml. (containing 3 mgm. nucleoprotein and 3 mgm. protein) was incubated with 30-ml. samples of 0·05 per cent deoxyribonucleic acid in 0·15 *M* sodium chloride, *p*H = 5·3.

At the end of digestion, samples were clarified by high-speed centrifugation, then dialysed against *M* sodium chloride and used for physical measurements and chemical analyses. The final recovery of deoxyribonucleic acid was 80–90 per cent, the losses being accounted for by the co-precipitation of an aliquot of deoxyribonucleic acid with the protein present in the enzymatic preparation.

It was found that very marked changes in the physical properties of deoxyribonucleic acid take place in the first few hours of enzymatic digestion. After 24–48 hr. at 37° C., however, no further significant changes are detectable, even on extending the time of digestion to 120 hr. The molecular weight of the final product was found to be $M_w = 5{\cdot}5 \pm 0{\cdot}5 \times 10^5$. The light-scattering results from it are compatible with a solution of monodisperse rods, having a molecular weight per unit length, M/L, of 200 ± 20/Å., a value which is in very good agreement with the Watson and Crick model for deoxyribonucleic acid[4]. A much higher degree of molecular asymmetry in the final, as compared with the starting, product was also indicated by Couette viscosimetry. The behaviour of the sedimentation constant parallels the drop in molecular weight. The value $S^\circ_{20,w.av.} = 5{\cdot}8\,S$ finally attained is also indicative of rod-like sedimenting units. Concurrently, the distribution function of sedimentation constants is remarkably narrower in the degraded deoxyribonucleic acid than in the starting preparations.

By using buffers of *p*H = 4·5–9·0 ($\mu = 0{\cdot}15$) as solvents for the deoxyribonucleic acid, it was observed that the enzymatic activity shows a very pronounced optimum close to 5·5. No degradation of deoxyribonucleic acid was evident at *p*H 7·0 or higher, in the presence of 0·03 *M* magnesium chloride (in 0·15 *M* sodium chloride, *p*H 5·3), at ionic strength $\mu = 0{\cdot}001$ or $\mu = 1{\cdot}0$ (sodium chloride, *p*H = 5·3), or when the crude enzymatic preparation had been previously kept 5 min. at 100° C.

It was also possible to show that, during the enzymatic digestion, no dialysable nucleotides were produced, and no significant changes of the absorption coefficient at 260 mμ were detectable. No differences were found between degraded *B*1*s* and *B*2, although the degradation of the former was slower than that of the latter.

It is evident from the above results that the fragments obtained by the enzymatic digestion of deoxyribonucleic acid investigated in this work do not originate in a random breakdown. All available experimental evidence suggests that they are true sub-units of the larger deoxyribonucleic acid particle, $M_w = 6\text{–}8 \times 10^6$. How these sub-units are bound together, what is the nature of their end-groups and whether they possess the same biological properties as the parent molecules are not yet known, and are now being investigated. It is likely, however, that the rod-like sub-units are connected in an end-to-end arrangement by some 'flexible joints' (sites of the enzymatic action) to form the larger deoxyribonucleic acid particle. It has already been shown that the light-scattering data for the latter are compatible with such a model[5].

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Effect of Glucose Concentration on Respiration of Rous Sarcoma and of Chorioallantoic Membrane

CRABTREE'S initial observation that glucose will depress the oxygen consumption of tumour cells has prompted further investigations of this phenomenon, most particularly in Ehrlich ascites cells[1] and in reconstructed systems[2]. It has been recently reported[3] that the virus-induced Rous sarcoma on the chorioallantoic membrane of chicken embryos shows a 'Crabtree effect'. The present communication reports the effect of glucose at various concentrations on the respiration of normal chorioallantoic membrane, and of Rous sarcoma growing on it, and extends the initial observations in this system to other parameters of glucose metabolism.

Standard lot *CT* 842 of Rous sarcoma virus was obtained from Dr. W. Ray Bryan and was stored in a 'dry-ice' chest until used. An inoculum of 0·2 ml. at a dilution of one-tenth of thawed virus in cold sterile saline solution containing 2 per cent inactivated horse-serum was dropped on to the chorioallantoic membranes of chicken embryos 9–10 days old by the false air-sac technique. Incubation at 36° C. during 6–7 days yielded Rous sarcoma. Control chorioallantoic membrane was prepared in the same manner except that virus was not added to the inoculum.

Chorioallantoic membranes used as normal controls were excised aseptically from embryos 16–17 days old. The tissue was cut into small pieces and washed thoroughly in cold saline. Tissue pieces of approximately 1 cm. square were removed from washing solution, blotted briefly on filter paper, and approximately 200 mgm. of wet tissue was added to each Warburg vessel. Rous sarcoma was dissected free of non-tumorous tissue and sliced with a Stadie-Riggs hand microtome. Tissue slices were washed likewise in cold saline and blotted on filter paper.

Tissues were incubated in a final volume of 2 ml. with Hanks's balanced salt solution in the absence of added bicarbonate, and without phenol red indicator. The *p*H was adjusted to 7·6 with dibasic phosphate (*M*/15). Glucose concentration in the medium was

Table 1. Oxygen Consumption of Normal Chorioallantoic Membrane and of Rous Sarcoma grown on Chorioallantoic Membranes

All values are expressed as μl. of gas per mgm. dry tissue per 4-hr. incubation period. Each value represents the average of duplicate determinations

Initial glucose (μmoles/ml.)	0	2·5	10	50
Chorioallantoic membrane	17·8	22·0	18·8	18·4
	18·0	21·0	16·8	18·4
	17·6	21·0	16·4	17·2
Rous sarcoma	7·2	5·6	7·2	6·0
	9·2	5·2	4·8	3·6
	8·6	4·4	5·2	5·6

varied from 0·5 to 50 mM. Air was the gas used in this manometric work. Initial and final glucose concentrations were determined on aliquots from the reaction vessels.

The manometric results of uninfected chorioallantoic membrane and of chorioallantoic membrane infected with Rous sarcoma virus are summarized in Table 1 and in Fig. 1. While glucose was without effect in depressing the oxygen consumption of chorioallantoic membrane, the respiration of Rous sarcoma was depressed by all concentrations of glucose tested. The results (Fig. 1) are suggestive of an increased depression of oxygen consumption with an increase in glucose concentration from 0·5 to 1·0 mM.

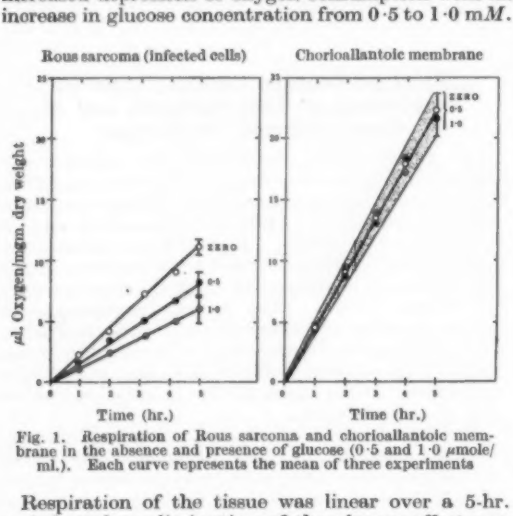

Fig. 1. Respiration of Rous sarcoma and chorioallantoic membrane in the absence and presence of glucose (0·5 and 1·0 μmole/ml.). Each curve represents the mean of three experiments

Respiration of the tissue was linear over a 5-hr. period, and no diminution of the glucose effect was observed with time. No further decrease in oxygen consumption of Rous sarcoma was observed with concentrations of glucose greater than 1 mM.

The utilization of glucose by both the chorioallantoic membrane and the Rous sarcoma was increased with increasing concentrations of medium glucose (Table 2). The Rous sarcoma uses much more glucose than the chorioallantoic membrane. However, the degree of depression of oxygen consumption observed in the Rous sarcoma is not necessarily related to the glucose utilization, that is, an increase in glucose utilization from 0·12 to 1·01 μmoles per mgm. dry tissue per 4 hr. did not result in increased depression of oxygen consumption.

Table 2. Effect of Substrate Concentration on Glucose Uptake by Normal Chorioallantoic Membrane and Rous Sarcoma growing on the Chorioallantoic Membrane

All values are expressed as μmoles per mgm. dry tissue per 4-hr. incubation period. Each value given is the average of six experiments

Initial glucose (μmoles/ml.)		2·5	10	50
Chorioallantoic membrane		0·08	0·17	0·69
	S.E.	± 0·01	± 0·03	± 0·09
Rous sarcoma		0·12	0·31	1·01
	S.E.	± 0·01	± 0·04	± 0·06

Thus it would appear that the Rous sarcoma virus offers a means of investigating the metabolic events in the induction of neoplastic growth. A comparison of biochemical changes between infected and non-infected cells is expected to reveal differences existing between normal and neoplastic tissues. The Rous sarcoma system offers a means by which sequential metabolic alterations may be observed during tumour development and growth.

The effect of glucose present at various concentrations has been investigated in Ehrlich ascites cells[4,5]. McKee *et al.*[4] have reported that glucose at very low concentrations stimulates oxidative metabolism of these cells and inhibits oxidative metabolism at higher concentrations. Glucose in 5·5 m.moles quantity produces a 'Crabtree effect' in ascites cells during the first hour of incubation, but the depression of oxygen consumption is not observed after this time, during which all the medium glucose was utilized. Block-Frankenthal and Ram[5] have observed no 'Crabtree effect' in ascites cells incubated with 2·5 m.moles of glucose, but a depression of oxygen consumption occurs with 10 m.moles. Further, it has been observed that with 2·5 m.moles of glucose, Ehrlich ascites cells completely utilize all the substrate during the initial equilibrium period[6]. Differences in effective concentrations of substrate in the ascites tumour and the Rous sarcoma may be due in part to the rate with which glucose of the same concentration (2·5 mM.) was utilized. Rous sarcoma uses less than 50 per cent of the added glucose during a 4-hr. incubation period.

Since the Rous sarcoma utilizes appreciably more glucose than the normal chorioallantoic membrane control, the possibility exists that a decreased rate of oxygen consumption by the tumour may be the result of increased glucose utilization.

It has been proposed that increased glycolysis may inhibit oxygen consumption by reducing the intracellular concentrations of inorganic phosphate and adenosine diphosphate[6]. Considering only tumour tissue, it would appear that within certain limits an increase in glucose will cause a further depression of oxygen consumption. However, if the effect of this sugar on the metabolism of normal cells is considered it would appear unlikely that glucose utilization *per se* can depress uptake of oxygen, since increasing the concentration of the substrate in the medium containing normal tissue will increase glucose utilization without changing the respiration.

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Crystalline Dihydropteroylglutamic Acid

THE preparation of dihydropteroylglutamic acid has previously been described by O'Dell *et al.*, who used catalytic hydrogenation of pteroylglutamate[1], and by Futterman, who carried out the reduction with sodium dithionite[2]. The acid prepared by catalytic hydrogenation is unsuitable for many biochemical studies, however, because it contains traces of tetrahydropteroylglutamic acid[3]. The material obtained by the method of Futterman is an amorphous discoloured preparation[2], but was found to be uncontaminated by tetrahydropteroylglutamic acid[3]. No analytical figures have been given for this material. By reducing purified pteroylglutamate with sodium dithionite according to the method of Futterman and twice precipitating the product by slow adjustment of the *p*H between strictly defined values, it has now been found possible to obtain dihydropteroylglutamic acid consistently as a white crystalline product giving analytical results agreeing fairly well with the theoretical values.

The procedure adopted was as follows. Ascorbic acid (1 gm.) was dissolved with mechanical stirring in about 5 ml. of water in a 25-ml. beaker. While stirring continued and continuous readings of the *p*H were made with a glass electrode 1 *N* sodium hydroxide was added slowly until the *p*H rose to 6·0. The volume of the solution was brought to 10 ml. by the addition of water and a solution of 38·2 mgm. of pteroylglutamic acid (purified as previously described[4]) in 1·6 ml. of 0·1 *N* sodium hydroxide added. Mechanical stirring was recommenced and 400 mgm. of solid sodium dithionite added. When all the dithionite had dissolved stirring was continued slowly for 5 min. at room temperature (22–25°). An ice-bath was then placed around the beaker and stirring continued until the temperature had fallen below 5°. Addition of 1 *N* hydrochloric acid from a burette at a rate of approx. 0·1 ml./min. was then commenced while the solution was stirred rapidly at 0–5°. Addition of hydrochloric acid was continued until the *p*H fell to 2·8 (approx. 5 ml. of 1 *N* hydrochloric acid required). After stirring the solution for a further 5 min. to allow complete precipitation, the precipitate was recovered by centrifugation (5 min. at 1,000*g*, temperature 0°) and the supernatant discarded. The precipitate, which was

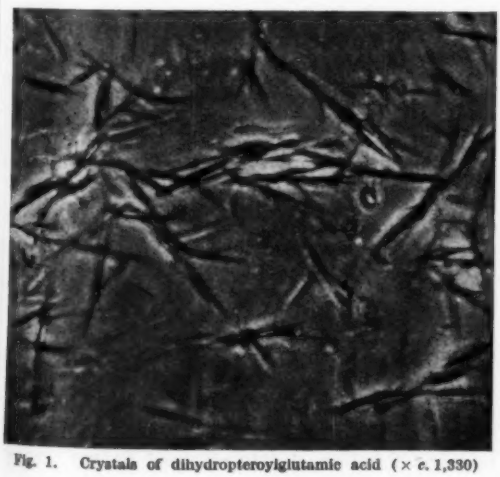

Fig. 1. Crystals of dihydropteroylglutamic acid (× *c.* 1,330)

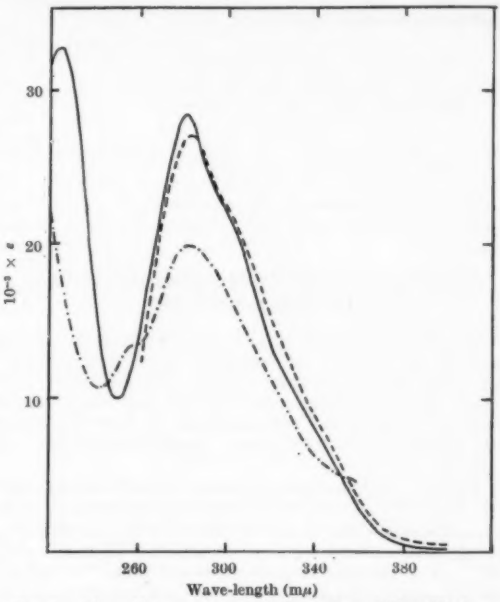

Fig. 2. Absorption spectra of solutions of crystalline dihydropteroylglutamic acid (0·03 m*M*) in 0·1 *M* potassium phosphate buffer (——); in 0·01 *N* sodium hydroxide (– –); and in 0·1 *N* hydrochloric acid (–.–.–)

mainly amorphous but contained some crystalline material, was re-suspended in 10 ml. of an ice-cold solution of 10 per cent sodium ascorbate, *p*H 6·0, freshly prepared as previously described. The suspension was returned to a 25-ml. beaker cooled in a nice-bath and mechanical stirring and continuous *p*H measurement recommenced. The bulk of the precipitate redissolved at this stage and the solution was between *p*H 5 and 6. If necessary the solution was adjusted to *p*H 6 by cautious addition of 1 *N* sodium hydroxide, and maintained at this *p*H while being stirred at 0° for a further 5 min. Under these conditions only crystalline material remained undissolved, causing marked birefringence. The dissolved dihydropteroylglutamic acid was crystallized from the solution by slow addition of 1 *N* hydrochloric acid performed exactly as previously. When crystallization was complete (5 min. after reaching *p*H 2·8) the heavy, white, birefringent suspension was centrifuged off as before and washed three times with ice-cold 0·001 *N* hydrochloric acid by suspending and centrifuging. After pipetting off the final supernatant the precipitate was quickly dispersed over the walls of the centrifuge tube, placed in a desiccator over phosphorus pentoxide and potassium hydroxide and the pressure quickly reduced to 0·02 mm. mercury. The solid, which was initially white, was stored in the desiccator in the dark until required. It became discoloured while stored in this way over a period of days, and discoloured even more rapidly when removed from the desiccator. Under the microscope the crystals appeared as fine, very small needles (Fig. 1). After preparation, a sample for analysis was dried for 16 hr. over phosphorus pentoxide (pressure 0·02 mm. mercury) at 25°, rather than at higher temperatures, in order to avoid decomposition. Calculated for $C_{19}H_{21}O_6N_7.2\frac{1}{2}H_2O$: C, 46·72; H, 5·37; N, 20·08 per cent. Found: C, 47·57; H, 5·62; N, 19·61

per cent. Absorption spectra for the crystalline material are shown in Fig. 2.

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Identification of 19-Norandrostenedione in Follicular Fluid

During the course of a recent investigation of the steroids present in the follicular fluid of the mare[1], an unidentified $\alpha\beta$-unsaturated 17-ketosteroid was detected, and it seemed possible that this might represent one of the intermediates in the conversion of androst-4-ene-3,17-dione (androstenedione) to œstrone.

Further work on this compound has now established its identity as 19-norandrost-4-ene-3,17-dione (19-norandrostenedione), the evidence being as follows: (1) R_F value of the unknown compound identical with that of authentic 19-norandrostenedione in ligroin/80 per cent methanol and hexane: benzene/formamide paper chromatographic systems; (2) ultra-violet, sulphuric acid and sulphuric acid–ethanol chromogen spectra of the unknown identical with those of authentic 19-norandrostenedione; (3) R_F value of the sodium borohydride reduction product of the unknown identical with the R_F value of 19-nortestosterone in a ligroin/80 per cent methanol chromatographic system; (4) R_F value of the acetate of this reduction product identical with that of 19-nortestosterone acetate in ligroin/80 per cent methanol and hexane/formamide systems; (5) failure of the unknown to be oxidized by chromium trioxide in pyridine, or acetylated by acetic anhydride in pyridine; (6) Zimmermann colour reaction of the unknown identical with that of authentic 19-norandrostenedione; (7) infra-red spectrum of the unknown identical in every respect with that of authentic 19-norandrostenedione.

Since there still remained the possibility that this compound might have been an artefact produced by the action of alkali on 19-hydroxyandrost-4-ene-3,17-dione, 20 μgm. of the latter substance was added to a sample of follicular fluid prior to extraction; however, this did not increase the amount of 19-norandrostenedione present in the final extract.

With the exception of two œstranediols reported by Marker *et al.*[2] in non-pregnant human urine, this is the first time that a non-aromatic 19-nor steroid has been found as a natural product. The mean concentration in eight samples of equine follicular fluid was 20 μgm./100 ml. fluid (range 4–45 μgm./100 ml.), and since it is present in considerable amounts, it is interesting to consider its possible biological significance.

It is now well established that androstenedione serves as a precursor in the biosynthesis of œstrogens, and as a result of *in vitro* studies with a number of endocrine tissues, it was suggested[3] that 19-hydroxyandrostenedione was an intermediate in this conversion. This has now been amply confirmed[4,5], and it has been shown that human placental microsomes *in vitro* can convert androstenedione to œstrone via 19-hydroxyandrostenedione. Since 19-oxoandrostenedione is also readily converted to œstrone, the following biosynthetic sequence has been proposed[6]:

androstenedione → 19-hydroxyandrostenedione → 19-oxoandrostenedione → œstrone

If the results of these *in vitro* experiments with human placental microsomes are an accurate reflexion of the events taking place in the ovary *in vivo*, one might expect to find 19-hydroxyandrostenedione and 19-oxoandrostenedione in follicular fluid. However, this is not the case; repeated attempts to identify 19-hydroxyandrostenedione in large quantities of equine follicular fluid have met with negative results, although recoveries of the pure steroid are satisfactory. Neither is there as yet any evidence to suggest that 19-oxoandrostenedione is present in equine follicular fluid. These negative results could be ascribed to the fact that both intermediates are so rapidly converted to œstrone that they do not accumulate in the ovary. It would be tempting to conclude that in the mare's ovary 19-norandrostenedione serves as an alternative intermediate in the conversion of androstenedione to œstrone. However, it must be remembered that 19-nortestosterone is a relatively inefficient œstrogen precursor *in vitro*[4].

I wish to express my thanks to Dr. R. K. Callow and Mr. Paul Miners for carrying out the infra-red analysis. Reference samples of 19-hydroxyandrostenedione and 19-norandrostenedione were kindly supplied by Dr. Maximilian Ehrenstein (Philadelphia) and the Medical Research Council Steroid Reference Collection (Dr. W. Klyne).

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Isolation of Purified Trichophytin

Commercial preparations of trichophytin[1] are generally aqueous extracts of the fungal mycelium (for example, *Trichophyton mentagrophytes*) together with a proportion of the culture medium. They thus contain a variety of substances which are not specific to trichophytin sensitivity and which may contribute in a variety of ways to the production of the skin reaction. In order to limit this non-specific response and to define the significance of the trichophytin reaction, an attempt has been made to isolate the antigenic material in a purified form and to obtain preliminary data as to its constitution.

The fungus, *Trichophyton mentagrophytes* (N.T.C. *D*281), was grown in a medium containing glucose (50 gm.), 1 per cent ammonium sulphate (100 ml.), 1 per cent sodium nitrate (100 ml.), 5 per cent acid hydrolysed casein (100 ml.), trace metal ions (1 ml.; ferrous sulphate, 200 mgm.; manganous sulphate, 100 mgm.; zinc sulphate, 100 mgm. in water, 100 ml.) and solutions *A* (540 ml.) and *B* (105 ml.) of

Krebs–Ringer phosphate[2]. After 4–6 weeks, the mycelium was collected, rinsed in distilled water and dried with acetone. Batches of this material were then extracted severally in an 'Ato-mix' with a variety of solvents including *M* sodium chloride, 5 per cent trichloracetic acid and ethylene glycol, filtered through 'Filtercel', dialysed and freeze-dried. All such extracts were antigenically active, but that produced by ethylene glycol extraction ('crude trichophytin') was preferred, since it combined high antigenicity with a low irritant content as determined on sensitized and control guinea pigs. The quantitative yield of 'crude trichophytin' from the acetone-dried mycelium was approximately 10 per cent using two extractions, 80 per cent of this being obtained in the initial extract. Crude trichophytin contained carbohydrate[3] and protein[4] in the ratio 10 : 1 (glucose and crystalline egg albumin as standards). Separation of crude trichophytin by paper electrophoresis in borate buffer *p*H 10 and treatment with the periodate–Schiff's reagent usually showed one major component together with an occasional faint second band moving rather faster towards the anode.

Purification of 'crude trichophytin' was effected by precipitation as a borate–'Cetavlon' complex[5]. Crude trichophytin was dissolved in water (500 mgm./30 ml.) and equal volumes of 'Cetavlon' (B.D.H. 10 per cent) and borate buffer (*p*H 7, 1 per cent) added. *N* sodium hydroxide was then added until precipitation occurred (*p*H 9–10). The precipitate was washed with water, dissociated by solution in 2*N* acetic acid and poured into ethanol. The resulting precipitate was washed successively with acetic acid–ethanol mixture, ethanol, ether, and dried ('Cetavlon' precipitated fraction). Any borate and 'Cetavlon' ions which remained were removed by passing an aqueous solution down a column of 'Zeokarb 225 (H^+)', dialysing the eluate and recovering the active material by freeze-drying to give purified trichophytin. The non-specific elements of the reaction, indicated by control animals, were almost completely eliminated while the biological response of both 'immediate' and 'delayed' reactions were practically undiminished, in guinea pigs sensitized by the injection of powdered sterile mycelium suspended in Freud's adjuvant (Table 1). Testing solutions could be ampouled and boiled for sterilization, thus avoiding the use of preservatives. Such 'purified trichophytin' showed only one component on paper ionophoresis in borate buffer *p*H 10.

Table 1. PURIFICATION OF TRICHOPHYTIN

Fraction	Guinea pig	Mean delayed reaction diameters ± *S.E.* at concentration of 0·2 mgm./ml.
Ethylene glycol extract (crude trichophytin)	Sensitized	10·8 ± 0·8
	Control	4·5 ± 0·9
'Cetavlon' precipitated fraction	Sensitized	8·6 ± 0·8
	Control	2·4 ± 0·4
Purified trichophytin	Sensitized	9·3 ± 1·5
	Control	0 ± 0

Special care was taken in the removal of the 'Cetavlon' since although the detergent itself appeared innocuous when skin tested in humans at a concentration of 0·1 mgm./ml., its complex with trichophytin produced violent skin reactions. This effect was not apparent when the preparation was first tested in guinea pigs. Passage down 'Zeokarb 225 (H^+)' ensures the complete removal of all the 'Cetavlon' and allows the purified trichophytin to be tested with confidence.

Ultracentrifugal analysis of trichophytin indicates that it has a relatively low molecular weight : 20,000–30,000. Chromatographic analysis of its hydrolysate showed it to contain glucose, mannose and the amino-acids leucine, valine, alanine, glycine, serine, threonine, glutamic acid, aspartic acid and arginine. Evidence from optical rotation ($[\alpha]_D$ + 88° in water) and infra-red spectra (absorption at 838 cm.$^{-1}$) indicated that these sugar residues (equivalent[6,7] to an 80 per cent polysaccharide content) were linked α-glycosidically. The purified trichophytin stained blue ($\lambda_{max.}$ 600 mμ) with iodine. Since this property was destroyed by incubation with α-amylase although antigenic activity was still retained, some at least of the glucose residues were probably present in a mould starch impurity. The ultra-violet absorption spectra of purified trichophytin showed a shallow peak at 270–280 mμ corresponding approximately to a 10 per cent peptide content. Trichophytin contained nitrogen 1·05 per cent (Kjeldahl). Peptide linkages were indicated by infra-red absorption peaks at 1,634 cm.$^{-1}$ (C=O) and 1,510 cm.$^{-1}$ (N—H) since N-acetamido sugars[8] were absent. Purified trichophytin was found to be free from nucleic acid[9,10].

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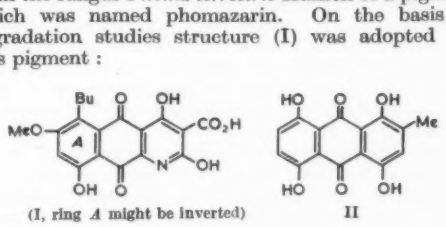
The Pigment of *Phoma terrestris* Hansen

SOME years ago Kögl *et al.*[1] reported the isolation from the fungus *Phoma terrestris* Hansen of a pigment which was named phomazarin. On the basis of degradation studies structure (I) was adopted for this pigment :



(I, ring *A* might be inverted) II

This representation attributed to phomazarin an aza-anthraquinone nucleus which would make it unique among natural products.

Accordingly, we have re-examined a culture of *Phoma terrestris* Hansen, obtained from the Central-

bureau voor Schimmelcultures (Baarn), and grown exactly as described by Kögl. There was isolated from the mycelium, by simple extraction processes, about 1 per cent by weight of cynodontin (II), m.p. 260° (found: C, 63·1; H, 3·9; $C_{18}H_{16}O_6$ requires C, 63·0; H, 3·5 per cent), readily identified as its tetra-acetate, by its infra-red spectrum, and by comparison with an authentic specimen kindly provided by Sir Alexander Todd.

Our experiments suggest the presence of at least one other pigment, but of no compound resembling phomazarin.

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HISTOCHEMISTRY

Enzymes Histochemically Demonstrable in the Earliest Phase of Wound Healing

During my work on local reactions in acutely injured skin, I was attracted by the early appearance of certain enzymes in the healing wound. Most authorities consider that in wound healing there is initially a metabolically inert lag phase of 1–4 days duration. Relatively little is known about the first appearance of enzymes during this phase. Balazs and Holmgren[1] found alkaline phosphatase at the wound margin 24 hr. after the injury. Fell and Danielli[2] and Firket[3] demonstrated during the lag phase that this enzyme was only present in the invading polymorphonuclear leucocytes. Needham[4] considered that acid phosphatase probably plays no part in repair. To the best of my knowledge there has been no previous report of the distribution of leucine aminopeptidase during the lag phase of healing.

I made an experimental study on guinea pigs, cutting circular skin wounds, 5 mm. in diameter, in a closely shaved dorsal area. The skin inside the circle was excised with fine scissors and the wounds were not covered. Groups of animals were killed ½, 1, 2, 4, 8, 16, 32, 64 and 128 hr. after wounding, and a flap of skin containing the circular wound was removed immediately. One-half of each skin flap was fixed overnight in cold neutral 10 per cent formalin. Cryostat sections, 10μ in thickness, of these halves were used for the histochemical demonstration of phosphatases. By means of coupling azo dye techniques, acid phosphatase[5] activity was visualized at *p*H 5·0 and alkaline phosphatase[6] at *p*H 9·2. The other half of the skin flap was frozen fresh and cryostat sections of it were stained for leucine aminopeptidase[7].

Leucine aminopeptidase activity was found to be present as little as 2 hr. after the injury (Fig. 1), gradually increasing up to 32 hr. There was a distinct positive area in the dermis a little beyond the wound edge. In addition to this, the lower layers of the stratum Malpighii showed moderate activity.

A little beyond the edge of the wound a clearly distinguished dermal zone exhibited strong acid phosphatase activity, beginning in a 4-hr. wound (Fig. 2) and increasing up to 16 hr. The uninjured

Fig. 1. Leucine aminopeptidase activity in a 2-hr. wound

epidermis showed intense activity all through the stratum Malpighii.

An active zone in the vicinity of the injured dermis could also be demonstrated in an 8-hr. wound by the technique for alkaline phosphatase (Fig. 3). The activity increased up to 32 hr. None of the epidermal strata nor the hairs showed any demonstrable alkaline phosphatase activity in the uninjured skin.

Except for some solitary invading polymorphonuclears, no distinct leucocytic zone was visible until 16–32 hr. had elapsed. These cells occupied almost the same area as had shown intense activity of enzymes much earlier. Thus leucocytes cannot be

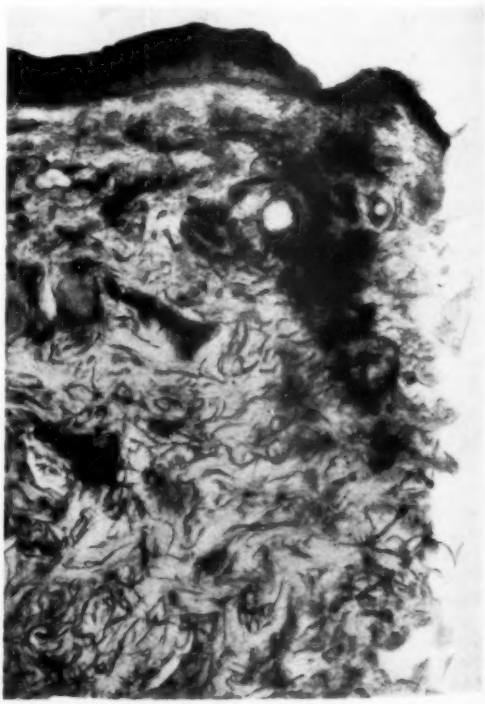

Fig. 2. Acid phosphatase activity in a 4-hr. wound

Fig. 3. Alkaline phosphatase activity in an 8-hr. wound

the main source of these enzymes. On the other hand, the most severely injured inner area of the wound showed no demonstrable enzyme activity. Consequently I suppose that the enzymes are not passively released by the seriously damaged cells in the innermost part of the wound. By contrast, in the outer zone the local cells are still able actively to produce enzymes in large amounts. The slight injury to the outer zone might serve as a stimulus activating local defence forces.

Besides functioning as a defence barrier, the enzymes appearing in the outer zone of the wound periphery may play a part in more specific regenerative processes. A synthetic action has been ascribed to leucine aminopeptidase[8], acid phosphatase[9] and alkaline phosphatase[10]. It seems probable, therefore, that the production of these enzymes represents one of the first steps in the repair process starting early in the so-called lag-phase of wound healing.

A more detailed investigation is in progress, the results of which will be published elsewhere.

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PHYSIOLOGY

Argininosuccinase Activity in Brain Tissue

A NEWLY recognized form of mental deficiency, probably caused by an inborn error of metabolism, has been described[1]. The unknown metabolite, now known to be argininosuccinic acid[2], found in this disease was present in the plasma, cerebrospinal fluid and urine. The concentration of this amino-acid was higher in the cerebrospinal fluid than in the plasma, suggesting that the compound is formed in the brain or some other organ in close association with the fluid. Apart from these patients, argininosuccinic acid has never yet been found, even in traces, in plasma, cerebrospinal fluid or urine of man or rats, nor can it be detected in extracts of rat liver, kidney or brain.

The compound was first described by Ratner, Petrack and Rochovansky[3] as an intermediate in the urea-cycle. Ratner and her colleagues described two enzyme activities concerned with metabolism of argininosuccinic acid present in liver and kidney tissue[4,5]. We have found that one of these, argininosuccinase, which catalyses the reaction :

$$\text{argininosuccinic acid} \rightleftharpoons \text{arginine} + \text{fumaric acid}$$

is also present in homogenates of rat brain, spleen and blood cells (but not in plasma) and in ox retina. Walker[6] has also reported argininosuccinase activity in brain, testis, spleen, pancreas, thymus, heart and skeletal muscle of the dog.

Argininosuccinic acid can be separated from other amino-acids by high-voltage electrophoresis on filter paper at *p*H 5 (ref. 7). Using this technique it can be demonstrated that argininosuccinic acid is formed when homogenates of the above tissues are incubated with arginine and fumaric acid at *p*H 7·5 and that ornithine is formed when the homogenates are incubated with argininosuccinic acid in the presence of added arginase.

A method similar to that described by Ratner[8] was used to estimate the argininosuccinase activity in rat brain and liver and also to study its distribution in various regions of the brain. A series of tubes, each containing 50 μM potassium phosphate buffer *p*H 7·5, arginase, at least 6 Van Slyke–Archibald units[9], and 3–15 μM argininosuccinic acid, in 0·5 ml., were prepared and warmed to 37° C. Rat tissue, obtained immediately after the death of the animal, was homogenized in seven volumes of ice-cold water or 0·1 *M* potassium phosphate buffer, *p*H 7·5. The homogenate was brought to 37° C. 1·0 ml. of 20 per cent metaphosphoric acid was added to the first tube followed by 0·5 ml. of homogenate. This tube was used for the zero value. 0·5 ml. homogenate was added to each of the other tubes, which were left to incubate at 37° C. for suitable intervals of time (for brain 20, 40, 60 min. during which time urea production was linear) before the reaction was stopped by the addition of 1·0 ml. of metaphosphoric acid. After centrifuging, urea was estimated in 0·5 ml. of the supernatants using Archibald's method as described by Ratner[8], except that 2·0 ml. acid reagent and 0·1 ml. of a 3 per cent alcoholic α-*iso*nitrosopropiophenone solution were used. Two series of control tubes : (1) as for whole system minus argininosuccinic acid ; (2) as for whole system minus homogenate, were run simultaneously.

Argininosuccinase activity was calculated from the urea formed in the experimental series, minus that of

the controls. From eight estimations, using male rats of the Wistar albino strain weighing 150–180 gm., the average activity of brain tissue was 2·2 μM/hr./gm. wet tissue (standard deviation 0·6) and for liver 200 μM/hr./gm. wet tissue (standard deviation 80). The activity observed in blood is less than 5 per cent of that of the brain of the same animal, so the activity observed for the brain cannot be attributed to included blood.

Using pig brain, all regions, so far as can be determined on a macro-scale, as well as the spinal cord and the meninges have some argininosuccinase activity. The cerebrum has only 40 per cent and the brain stem 70 per cent of the activity of the cerebellum per gram wet tissue (Table 1). An attempt has been made to localize further these activities. No difference could be found in the various regions of the cerebrum; but the white matter always had lower activity than the grey. A similar difference in activity between the white and grey matter of the cerebellum was not observed. The arginase activity of the pig brain homogenates was also determined, and was found to be distributed differently. The cerebrum and cerebellum have approximately the same activity and in both the activity is greater in the grey than in the white matter. This difference is eliminated if the arginase activity is determined in the presence of added manganese.

Table 1. Distribution of Argininosuccinase and Arginase Activities in Pig Brain

Region	Argininosuccinase (μM/hr./gm. wet tissue)	Arginase (μM/hr./gm. wet tissue)
Whole brain	1·5	10·1
Cerebrum, grey	1·3	11·6
white	0·9	8·6
Cerebellum	3·2	11·9
Brain stem	2·3	7·3

The observed distribution of argininosuccinase activity in brain tissue (though it may be due to the distribution of an unrecognized co-factor, or to an inhibitor) is probably a reflexion of the cell densities of the various regions. It seems likely, however, that the activity of some cell types may be greater than others, for the cerebellar activity is only 2·5 times that of the grey cerebrum, whereas Nurnberger and Gordon[10] have shown that the total cell density of the cerebellum is about four times greater than that of the grey cerebrum. Similarly, when considered on a cell basis using the data of Nurnberger and Gordon for total cell density, the activity of the liver per cell is only 45 times as great as that of the brain.

Sporn, Dingman, Defalco and Davies[11,12] have recently shown that urea can be synthesized by rat brain *in vivo*. Argininosuccinase is one of the enzymes of the urea cycle, as modified by Ratner, so it seems likely that some at least of the urea produced by the brain may be formed by a mechanism similar to that of the liver. (Ratner has evidence for the occurrence of argininosuccinase and also of the condensing enzyme responsible for synthesizing argininosuccinic acid from citrulline and aspartic acid in the brains of rats, steers and monkeys—private communication.) It has been suggested that the primary function of the ornithine 'cycle' may be the synthesis of arginine and citrulline[13] rather than of urea. If the complete set of enzymes does exist in the brain, such a function would be particularly interesting.

One of us (S. T.) wishes to thank the Mental Health Fund for a grant which enabled her to carry out this work. She would also like to thank Dr. L. M. Kerly for her advice and constant encouragement.

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An Effect of Insulin on Production of Glucose during Hepatic Glycogenolysis

In earlier work the effect of a prolonged intravenous infusion of insulin on the utilization and production of circulating glucose was investigated in the trained, unanæsthetized normal dog in the post-absorptive state with the aid of intravenously administered ^{14}C-glucose[1]. The plasma glucose concentration and specific activity were determined at frequent intervals, and from these values were calculated the rates of production of hepatic ^{12}C-glucose and total glucose-uptake by the tissues[2]. It was shown that insulin brought about a hypoglycæmia primarily by increasing the uptake of glucose by the tissues. The rate of production of hepatic ^{12}C-glucose, although temporarily somewhat reduced soon after the insulin infusion was begun, usually rose during the course of the infusion to higher than normal levels, but not sufficiently to restore the plasma glucose concentration to its pre-insulin level. When the insulin infusion was stopped, there was a marked further increase in the production of hepatic ^{12}C-glucose which restored the plasma glucose concentration to its control-level. From these findings it was concluded that, during the period of insulin infusion, the production of ^{12}C-glucose was restrained in spite of severe hypoglycæmia[1].

To elucidate this effect of insulin, experiments have been carried out in which production of hepatic ^{12}C-glucose was raised by treatment with phloridzin or glucagon prior to the infusion of insulin. Phloridzin, injected subcutaneously in normal dogs in the post-absorptive state 2 hr. prior to administration of ^{14}C-glucose, caused a marked glucosuria which continued throughout the experiment. However, the plasma glucose concentration was maintained at near the normal level by a several-fold increase in production of hepatic ^{12}C-glucose. An insulin infusion (0·07–0·14 u./kgm./hr., intravenous) started 4 hr. after the phloridzin injection reduced production of hepatic glucose to about the pre-phloridzin level. When the insulin infusion was stopped, the production of hepatic

glucose rose again to its high pre-insulin level. The plasma glucose concentration was reduced as usual by insulin and rose when the insulin infusion was stopped[3].

In an attempt to eliminate liver glycogen as a source of the ^{12}C-glucose produced by the liver, normal dogs were depleted of liver glycogen by a 2-day fast and continuous phloridzination during the last 24 hr. of the fasting period. These animals exhibited a glucosuria, moderate hypoglycæmia and normal or slightly raised rate of production of hepatic ^{12}C-glucose. The infusion of insulin (0·07–0·14 U./kgm./hr., intravenous) lowered the concentration of plasma glucose, but did not reduce production of hepatic ^{12}C-glucose, in contrast with the effect of insulin in acutely phloridzinized dogs.

In view of these findings, the effect of insulin was studied in normal dogs in the post-absorptive state while hepatic glycogenolysis was being stimulated by glucagon. The infusion of glucagon (4 μgm./kgm./hr., intravenous) markedly increased production of hepatic ^{12}C-glucose and raised the concentration of plasma glucose. An insulin infusion (0·14–0·33 U./kgm./hr., intravenous), superimposed on the glucagon infusion, lowered the elevated rate of production of hepatic ^{12}C-glucose. On termination of the insulin infusion, with continuation of glucagon administration, the rate of production of the hepatic ^{12}C-glucose and the plasma glucose-level increased again.

These observations demonstrate that insulin promptly inhibits production of glucose at times when hepatic glycogenolysis is taking place and fails to do so when liver glycogen has been depleted and when the production of glucose by the liver probably originates by gluconeogenesis (namely, the 2-day fasted, phloridzinized animal). It can be inferred from these observations that insulin should reduce the net breakdown of hepatic glycogen brought about by glycogenolytic agents. Earlier evidence for such an effect of insulin has been reviewed by Cori[4].

The restraining effect of insulin, described earlier, is presumably exerted by a similar mechanism. Thus, when the concentration of blood glucose is lowered by a continuous infusion of insulin, release of physiological glycogenolytic agents is evoked by the hypoglycæmia. So long as the infusion of insulin continues, the ability of these agents to bring about liver glycogenolysis is limited. When the insulin infusion is terminated, this restraint is removed, and the resulting increased glycogenolysis causes a marked increase in the production of ^{12}C-glucose.

The small temporary effect of insulin in reducing production of hepatic ^{12}C-glucose, which we have observed when an insulin infusion is first begun, could be due to a similar effect of insulin on that small portion of the production of glucose which is arising by hepatic glycogenolysis in the normal unanæsthetized dog in the post-absorptive state. It is also conceivable that dogs with initially high blood-sugar-levels due to fright or anæsthesia or dogs having impaired hepatic circulations and maintained on high carbohydrate diets might have larger fractions of their production of hepatic glucose derived from glycogenolysis, and that this might be responsible in some part for the larger initial inhibitory effects of insulin on the production of hepatic glucose which have been reported by others.

The present observations do not permit a definite conclusion as to the mechanism whereby insulin reduces the production of glucose during hepatic glycogenolysis. Interference with phosphorylase action would produce the findings observed; however, stimulation of glycogen synthesis via the uridine diphosphate glucose pathway[5] could also bring about a net decrease in glucose production, but any mechanism of this kind would have to include a special provision to account for the fact that a decrease in production of glucose is observed only during glycogenolysis. Whether insulin exerts an inhibitory effect on production of glucose by acting directly on the liver or by indirect means cannot be stated at the present time.

The present experiments suggest that insulin administered to the intact animal promptly inhibits production of hepatic glucose when glycogenolysis is taking place or is being called for by glycogenolytic factors evoked by hypoglycæmia. This action of insulin would appear to be of physiological significance.

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Production of Free Water in the Mammalian Fœtus

The hypotonicity of the fœtal fluids and urine of many mammalian fœtuses is well known[1], and attempts have been made to explain it in terms of active transport of water or of sodium[2]. In certain conditions, the production of osmotically free water may be the physico-chemical consequence of active anabolism. If the anabolism occurs in a medium isotonic with normal extracellular fluid and is accompanied by little or no catabolism, water will be freed. This situation obtains in the mammalian fœtus which, while showing little catabolic activity, is rapidly synthesizing the large molecules of its cell constituents from small molecules passing through the placenta into its circulation. The osmotic freeing of water by this process is sufficiently great to account for the hypotonicity of the fœtal fluids and urine.

In making a rough calculation one may consider protein synthesis only. On the 23rd day of gestation the rabbit fœtus contains 0·62 gm. protein and on the 27th day, 1·7 gm. protein[3], so in this four-day period it has synthesized 1·08 gm. protein. If one assumes: (*a*) that mean weight of the protein molecules formed is about that of tropomyosin (mol. wt. 80,000; 670 amino-acid residues/mol.), and (*b*) that the amino-acids used in protein synthesis are presented to the fœtal tissues as undissociated molecules in a solution of osmolar concentration 300 milliosmoles/l., one can calculate that during this four-day period of gestation 0·0135 millimole of 'tropomyosin' has been formed from 9·1 millimoles of amino-acids, which would be contained in 30·4 ml. of solution. The 'tropomyosin' thus formed (assuming that the cell contents are isotonic with extracellular fluid) would require only 0·05 ml. water for its solution. The synthesis has therefore set free 30·35 ml. water. Unless the placenta removes this volume of water in excess of solute, some

water will accumulate on the fœtal side of the placenta and dilute the fœtal fluids or urine. Strongly hypotonic allantoic fluid is in fact found in ungulates, the placenta of which is less permeable than that of rabbits[4].

This rough calculation relates not, of course, to the absolute exchange of water between the maternal and fœtal organism, which is known to be very large[5], but simply to the osmotic freeing of water by the conversion of many small molecules into a few large ones. The synthesis of protein will also cause a comparatively small absolute increase in water by release of metabolic water in the formation of peptide bonds.

A similar process in actively growing young plants has been described by Lundgårdh[6]. Wheat seedlings grown in salt-free sugar solutions synthesize protein from the sugar together with nitrates already present in the plant; and during this process the tissue fluid (collected as bleeding sap from the cut end of the stem) becomes hypotonic, as a result of the 'extra water' released by the decrease in the number of molecules present. It is suggested that the hypotonicity of mammalian fœtal fluids and urine may result from an analogous process.

I am indebted to several colleagues for helpful discussions of this point.

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PATHOLOGY

Inhibition of Exogenous and Endogenous Pyrogens by Lysozyme

Since lysozyme has been used for therapeutic purposes it has been observed that a rapid fall of temperature may follow its administration. Experiments were, therefore, planned to find out if Fleming's bacteriolysin prevented the rise of temperature caused by exogenous and endogenous pyrogens in rabbits.

Subcutaneous injection of 400 mgm./kgm. of lysozyme were found to reduce to some extent the effects of the intravenous administration of an exogenous pyrogen (pyromen), whereas subcutaneous administration of similar amounts of gelatin did not. Since smaller doses of lysozyme had no effect, it was considered possible that the large doses were producing their effect by interacting with endogenous pyrogen which, as it is well known, is responsible for most of the rise of temperature observed after injecting exogenous pyrogens[1–3].

This assumption has been proved to be correct in experiments carried out by means of Bennet and Beeson's technique[4]. Rabbits were prepared by shaving the abdomen, and 350 c.c. of physiological saline containing 60 units of penicillin and 0·8 mgm. of streptomycin per c.c. was infused into the peritoneal cavity, slowly, so that the infusion was completed in 3 hr. The animals were kept on their backs for 4 hr. after termination of the injection. Then the abdomen was opened and all fluid in the peritoneal cavity was aspirated into sterile Erlenmeyer flasks.

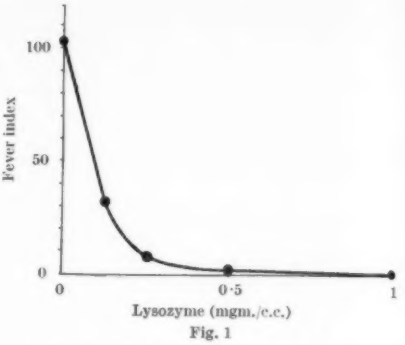

Fig. 1

The peritoneal fluid, which was centrifuged until it was clear, produces the typical hyperthermia due to endogenous pyrogen if it is administered intravenously to rabbits (dose, 10 c.c. per 2-kgm. rabbit). If sterile lysozyme hydrochloride is dissolved in the saline solution to be infused into the abdominal cavity at a concentration of 0·5 mgm./c.c., then peritoneal fluid cleared by centrifugation does not produce hyperthermia, when it is injected intravenously into rabbits (dose, 10 c.c. per 2-kgm. rabbit).

In controls carried out with sterile gelatin, utilizing the same concentrations, the peritoneal fluid cleared by centrifugation can produce the hyperthermia characteristic of an endogenous pyrogen.

Measuring the fever curves with a planimeter, it is possible to determine the 'fever index' utilized by Beeson[5]. The antipyrogenic action of lysozyme is expressed graphically in Fig. 1, in which values of the 'fever index' are plotted as ordinates and values of lysozyme concentration as abscissæ.

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Effects of Hexamethonium Bromide and β-Amino Propionitrile on the Tensile Strength of the Aorta of Mice

Beaven and Murphy[1] suggested that the ganglion-blocking agents, hexamethonium bromide and pentolinium, might weaken the aortic media, because nine of a series of 44 hypertensive patients under treatment with these agents died suddenly from dissecting aneurysm of the aorta. Six of the nine fatal cases had malignant hypertension. Although in a large autopsy service we have observed this association only in one case of malignant hypertension treated with 'Darenthin', we decided to test the hypothesis by comparing the effects of hexamethonium bromide alone and in association with the lathyrous factor β-amino propionitrile on the static tensile strength of the aorta in normal mice. The latter compound is well known to weaken the aortic media in experimental animals by an antimaturant action on collagen[2].

White mice of both sexes aged 3–4 weeks were used in five successive experiments each comprising 60 animals. This age-group was chosen because Ponseti and Shepard[2] found that the most marked aortic lesions were produced in the rat when treatment with a lathyrous diet was begun before the age of 4 weeks. Further, Gillman and Hathorn[4] suggest that animals immediately after weaning should be used to assess the aortic effects of β-amino propionitrile because at this time aortic growth and remodelling are maximal.

In each experiment the 60 mice were divided at random into four groups of 15 animals. Each experiment lasted 3 weeks. Animals in group 1 received a single daily subcutaneous dose of 5 mgm. of β-amino propionitrile. Those in group 2 were given two doses daily each of 0·5 mgm. of hexamethonium bromide. This dose was determined after preliminary trials, which showed that a single dose of 1·5 mgm. caused rapid convulsive death and that 0·5 mgm. was the maximum dose which could be given over a period of 3 weeks without causing significant mortality. Group 3 received each day the combined regime of a single dose of 5 mgm. of β-amino propionitrile and two daily doses of 0·5 mgm. hexamethonium bromide. The β-amino propionitrile and the first dose of hexamethonium were given close together each morning and the second dose of hexamethonium each afternoon. Group 4 animals were uninjected controls.

At the end of the experimental period of 3 weeks the mice were killed in random order over a period of 3 days, during which no drugs were given. The thoracic aorta was carefully dissected free from fascia, suspended between clamps and weights added to the lower clamp until the aorta broke.

The breaking strain was found to vary considerably between animals treated alike. Results are shown in Table 1.

Table 1. Breaking Strain (gm.) of Aortic Media

	Control	β-Amino propionitrile alone	Hexamethonium alone	β-Amino propionitrile + hexamethonium	Experiment mean
Experiment 1	44·2	38·8	48·0	36·6	42·1
Experiment 2	47·6	44·7	42·7	35·8	42·8
Experiment 3	47·2	39·3	47·6	40·3	43·5
Experiment 4	44·3	37·3	38·4	38·3	39·5
Experiment 5	44·7	32·5	40·3	34·8	38·1
Treatment mean	45·7	38·7	43·4	37·2	40·5

The standard errors of the difference between individual treatment means was 1·94. It was therefore apparent that β-amino propionitrile produced a significant weakening of the aortic media, but that treatment with hexamethonium bromide did not do so, nor did it potentiate the weakening effect of β-amino propionitrile.

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BIOLOGY

De novo Origin of the Nuclear Membrane

The behaviour of the nuclear membrane in prophase and telophase is indeed one of the most attractive features of mitosis for the electron microscopist and cytologist[1]. This was recently emphasized by Porter and Machado[2] in their review of the literature preceding their own electron microscope observations of mitotic onion root cells. In summary, the nuclear membrane or envelope is formed either by a coalescence of vesicles derived from the endoplasmic reticulum at the chromosome surface, or, as in the case of the onion cells, by slender lamellar units of the endoplasmic reticulum draping themselves around the chromosomes at the poles in telophase. Not one of these studies shed any light on the intriguing question posed by Bernhard[3] regarding the possibility of a *de novo* origin for the nuclear membrane.

In a problem like this, the selection of proper research material is perhaps more important than formulation of the original proposition. In such material, the number of cells undergoing mitosis should be unusually high, and the cells should not contain much endoplasmic reticulum and relatively few mitochondria. Electron microscope studies for an entirely different problem revealed that fœtal liver (human and rat) is an excellent tissue for a number of cytological problems[4]. At certain stages of development, the actively proliferating erythroblastic cells may outnumber the hepatic cells and even deform them by encroachment. In the youngest erythroblasts, fixed with buffered osmic acid, the sparse slender profiles of endoplasmic reticulum disappear gradually by fragmentation into small vesicles. Basophilic erythroblasts (normoblasts), which are characterized by an abundance of ribonucleoprotein particles and a small volume of endoplasmic reticulum or an involution of it[5,6], are mitotically quite active.

During prophase the nuclear membrane leaves the surface of the contracting chromatin, fragments and migrates towards the cell periphery. It is apparently metabolized after further fragmentation into vesicles. Although this lamellar structure may persist into the telophase stage, it is not related to the reconstitution of the new nuclear membrane.

Reconstitution of the nuclear membrane occurs first, multicentrically, around the periphery of the daughter cell chromosomal mass farthest away from the interzonal spindle fibres (Fig. 1). Examples of aberrant chromosomal masses and differential mitosis further emphasize that remnants of lamellar endoplasmic reticulum are not required for the formation of the nuclear membrane in erythroblasts.

This evidence for the *de novo* origin of the nuclear membrane assigns to the chromosomal mass a much more important role in its formation than has been possible in previous electron microscope studies because basophilic erythroblasts are remarkably free from lamellar and vesicular endoplasmic reticulum. This interpretation is in keeping with light microscope studies showing that the nuclear membrane is first formed in telophase by the coalescence of membranes from the cytoplasmic surface of each of the chromosomal vesicles[7]. Hence, the nuclear membrane stands in a direct genetic relation to the chromosomal parts[8],

Fig. 1. Electron micrograph of a portion of the chromosomal (*Ch*) mass in telophase of an erythroblast from a 15-day rat fœtal liver. Arrows indicate the reconstitution of the nuclear membrane. A remnant of the nuclear membrane from the preceding prophase nucleus is shown at *R*. A portion of a mitochondrion is in the upper left corner. (× 16,666)

and in the case of basophilic erythroblasts, it would be actively involved in the nucleo-cytoplasmic exchange of basophilic material.

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Auxin Control of Protein-Levels in Detached Autumn Leaves

It is well established that when mature leaves are detached from the plant the protein-level in the blade falls[1]. It has also been demonstrated by both Vickery, Pucher, Wakeman and Leavenworth[2] and Mothes and Engelbrecht[3] that an external supply of carbohydrate or of nitrogenous substances such as nitrates, ammonium salts or urea, will only slow down the rate of the protein degradation. If detached leaves are maintained in nitrogen, however, the fall in protein can be considerably retarded without the addition of metabolites[4], while the reduction in protein-level can be entirely suppressed under normal aerobic conditions once root initials have been formed on the petiole[3]. The retention of protein in detached but rooted leaves caused Chibnall[5] to propose that a root factor, possibly hormonal in nature, is essential for the synthesis of protein in leaf tissue. In this connexion the findings of Richmond and Lang[6] and Person, Samborski and Forsyth[7] are of considerable interest. The former workers showed that when detached unrooted leaves of *Xanthium* were kept with their petioles in 5 or 10 mgm./l. kinetin the loss of protein was retarded, and the chlorophyll and green colour of the blade were maintained. Person *et al.*[7] reported similar effects on detached wheat leaves floated on solutions of benzimidazole. Later, Mothes, Engelbrecht and Kulajewa[8] elegantly demonstrated that when solutions of kinetin were applied locally to the surface of mature tobacco leaves the original levels of protein and chlorophyll were maintained in the treated areas; furthermore, nitrogenous compounds applied to other parts of the leaf moved towards the parts treated with kinetin. In a recent communication[9], one of us directed attention to the importance of auxins in the control of physiological changes occurring during the autumn senescence of both attached and detached leaves. Local applications of the *n*-butyl ester of chlorinated phenoxyacetic acids to the surface of green autumnal leaves of cherry resulted in a retention of photosynthetically active chlorophyll and the conservation of alcohol-insoluble nitrogen in the treated areas. In contrast, untreated parts and control leaves became completely yellow and showed a greater reduction in the protein-level. These investigations have now been extended, and more detailed work has revealed that the total protein-levels in the auxin-treated areas of the leaf may be wholly maintained for periods of more than two weeks, during which time the total protein in control leaves and untreated parts of the treated leaf may fall to half the original values.

Fully green leaves were removed from trees of *Prunus serrulata* in late October. A drop (1·9 µl.) of an ethanol solution of the *n*-butyl ester of 2,4-dichlorophenoxyacetic acid was applied to the upper surface of the lamina, on each side of the main vein, to give a total dose of 25 µgm./spot (acid equivalent). Control leaves were treated with ethanol. The leaves were maintained in high humidity in an unheated greenhouse in normal day-length. The cut ends of the petioles dipped into beakers containing distilled water which was changed daily.

Within 6 days, control leaves and the untreated areas of the treated leaves began visibly to lose chlorophyll and turn yellow, and by the eleventh day, the areas treated with 2,4-dichlorophenoxyacetic acid remained as green islands of tissue in an otherwise yellow leaf. At appropriate intervals the levels of different nitrogen fractions were determined in disks of tissue, 1·5 cm. in diameter, cut from control leaves and from treated and untreated parts of the treated leaves. Determinations of total, 80 per cent ethanol-insoluble and 80 per cent ethanol-soluble fractions of nitrogen from duplicate samples of tissue were carried out by the usual micro-Kjeldahl techniques. After correcting for the small changes that occurred in the fresh weight of the leaf and hence in the leaf area it could be shown that there was no change in the total nitrogen value for the different areas of the blade. Results are therefore expressed as the ratio of 80 per cent ethanol-insoluble nitrogen

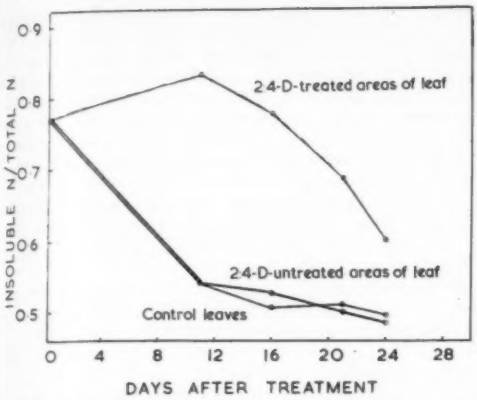

Fig. 1. Ratio of 80 per cent ethanol-insoluble nitrogen/total nitrogen in control leaves and in areas treated and untreated with 2,4-dichlorophenoxyacetic acid in blades of detached autumn leaves of *Prunus serrulata*. The departure from the mean for each individual point varies from 0–6·5 per cent

to total nitrogen. This measure of protein nitrogen within the tissues at different times after treatment is shown in Fig. 1. It is clear that while nearly 50 per cent of the protein is degraded in control and untreated areas the protein-level is maintained in the tissues treated with 2,4-dichlorophenoxyacetic acid. Further estimations have shown that in the control and untreated tissue, there is an increase in α-amino, amide and ammonia nitrogen corresponding to the decrease in protein.

Treatment of detached cherry leaves with 2,4-dichlorophenoxyacetic-ester labelled with carbon-14 in the carboxyl group, followed by detection of carbon-14 by autoradiography, showed that the labelled carbon is retained entirely within the areas of tissue which remain green. It was also found that neither the continuous supply to the petioles of an aqueous solution of kinetin at 25 mgm./l. nor a local daily aqueous spray of kinetin at 100 mgm./l. was effective in delaying protein degradation or preventing yellowing of the blade. Indole-3-acetic acid was equally ineffective, but spot applications of indole-3-aceto-nitrile produced visible responses similar to those described for 2,4-dichlorophenoxyacetic acid.

Respiratory measurements on leaf disks from control leaves or from untreated areas of leaves treated with 2,4-dichlorophenoxyacetic acid revealed a similar and continuing increase in oxygen-uptake starting after detachment from the tree and reaching a peak some ten days later. Concomitant with this increase in oxygen consumption there was a rapid fall in protein-level and a loss of chlorophyll. This phase was followed by a continuous decline in oxygen consumption corresponding to the further slow decrease in protein-level. In the areas treated with 2,4-dichlorophenoxyacetic acid the period of increasing oxygen consumption was postponed by some twenty days from the time of detachment and treatment, and, as with the control and untreated areas, the peak of oxygen-uptake again corresponded with the period of rapid protein degradation. By the end of the experiment (24 days) the tissues in the treated areas were still light green and capable of fixing labelled carbon dioxide in the light. At no stage was there any visible indication that root formation, cell division or other morphological change had occurred in the treated leaves.

Since the areas which remain green are the only ones in which carbon-14 can be detected after treatment with carbon-14 labelled 2,4-dichlorophenoxyacetic acid, and since the retention of chlorophyll and protein is restricted to these areas, it must be concluded that these effects on chlorophyll and protein are due to a direct effect of treatment with 2,4-dichlorophenoxyacetic acid. In both the yellowing control leaves and the untreated parts of the treated leaves it is clear that degradation of protein must exceed synthesis.

A number of postulates can be advanced to explain the ways in which 2,4-dichlorophenoxyacetic acid may control the protein-levels in these senescing leaves.

(1) The retention of actively photosynthetic chlorophyll might lead to a sparing of protein by increasing the supply of carbohydrates. However, Vickery, Pucher, Wakeman and Leavenworth[10] have shown that active photosynthesis and even accumulation of carbohydrate in mature detached tobacco leaves does not, in fact, retard protein breakdown. It is improbable, therefore, that the effect of 2,4-dichlorophenoxyacetic acid can be accounted for in terms of increased carbon substrates.

(2) Racusen and Aronoff[11] showed that in soya bean leaves the incorporation of labelled carbon dioxide into the amino-acids of protein decreased with increasing time after detachment from the plant. It may be, therefore, that 2,4-dichlorophenoxyacetic acid acts by preventing a decline in the rate of incorporation of amino-acids.

(3) It is also possible that protein turnover is completely blocked by treatment with 2,4-dichlorophenoxyacetic acid, so that neither synthesis nor degradation occurs.

Many metabolic processes have now been shown to be correlated with the hormone status of the plant. The evidence presented here suggests that auxins are controlling factors in certain pathways of protein metabolism.

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Influence of Light from an Infra-red Bulb on the Mutagenic Effect of Colchicine on *Sorghum*

True-breeding diploid mutants have been found to arise from colchicine-treated *Sorghum* seedlings of the true-breeding lines, Experimental 1 and Experimental 3[1–5]. Their true-breeding nature is similar to that obtained after many generations of selfing so that they appear to be immediately homozygous for the new characteristics. Some non-true-breeding mutants also occur. It was proposed that the true-breeding condition might arise by a somatic reductional division of the chromosomes, similar to that observed by Huskins[6], with subsequent restoration to the diploid number, and that the mutant condition might arise through concentration of chromatin from one of the original ancestors from which Experimental 3 had been derived. However, from cytogenetic studies of hybrids between true-breeding mutants and their untreated full sibs, the genetic changes appear to be due to gene mutations[4,7–9]. Tests of the somatic reduction hypothesis using chromosome markers (recessive genes and reciprocal translocations) in the heterozygous condition in sorghum and other materials have not been decisive[1,7,10] except for one case in flax (gene markers) which indicated its seeming validity[11].

The definition of a laboratory method for the production of true-breeding mutants after colchicine treatment has been found to be of paramount importance from the point of view of testing the hypothesis of somatic reduction since variable success results under greenhouse conditions. For this purpose the influences of environmental factors on the induction of mutants are being determined. Recent investigations involving more than 1,000 colchicine-treated seedlings have been carried out using aseptic cultures kept under light and temperature conditions with various degrees of control[12]. Only four mutated plants, none true-breeding, were obtained. The problem, therefore, was to identify the particular factors responsible for the difference in results between sand jars in the greenhouse, which had given as high as 42 per cent true-breeding mutants[2], and aseptic cultures under light and temperature conditions controlled to varying degrees, which gave very few mutants, none true-breeding. Light was a possible factor since most of the seedlings in aseptic culture were grown in a box with artificial light, or in the laboratory, or under shades in the greenhouse, while those in sand jars were grown in the greenhouse without shades. Infra-red light was investigated since these rays penetrate glass, have been found to modify chromatin re-arrangements induced in *Drosophila*[13] and in *Tradescantia*[14], and have been shown to play an active part in the control of many aspects of growth and differentiation[15].

In experiments in Table 1, untreated and treated seedlings of line Experimental 3 were grown in glass-covered jars on sand with tap-water and in test-tubes on agar both with full nutrient and with distilled water. Treatment consisted of application of 0·5 per cent colchicine in lanolin to the coleoptiles immediately after germination. Comparisons were made between shaded and unshaded conditions in the greenhouse and continuous illumination from a 'Heat Ray' bulb (infra-red, 250 W.) at approximately 78° F. for seven days immediately after treatment. Progeny tests were made of surviving plants from these experiments.

Light conditions and medium influenced both survival of treated seedlings and induction of mutants. Infra-red light cannot be considered the only factor precipitating the appearance of true-breeding mutants since changing the culture from sand to agar prevented their induction. It may be of importance that mutants appeared only under conditions which gave high mortality. This observation agrees with previous findings that although agar with or without nutrients increased survival of treated seedlings over that in sand jars, the number of mutants induced by colchicine treatment is decreased by this and other improved growing conditions[12]. The high rate of mortality associated with the induction of true-breeding diploid mutants suggests that the balance between stress conditions causing death and those causing origin of a mutated shoot, which displaces

Table 1. Incidence of True-breeding Diploid Mutants and Polyploid Plants, as indicated by Phenotype and verified by Progeny Tests, from Untreated and Colchicine-treated Sorghum Seedlings (Line Experimental 3) with Different Illumination and Media

Medium	Greenhouse				Infra-red bulb (7 days)	
	Shaded		Unshaded			
	Untreated	Treated	Untreated	Treated	Untreated	Treated
1957 Experiment						
Sand, tap-water						
Original number	20	20	—	—	20	60
Survivors	19	7	—	—	13	9
Polyploids	0	0	—	—	0	0
True-breeding diploid mutants	0	0	—	—	0	4
1958 Experiments						
Sand, tap-water						
Original number	20	60	10	20	30	80
Survivors	19	33	10	5	27	6
Polyploids	0	0	0	1	0	0
True-breeding diploid mutants	0	0	0	0	0	1
Agar, full-nutrient*						
Original number	—	—	10	20	10	20
Survivors	—	—	10	20	10	15
Polyploids	—	—	0	2	0	4
True-breeding diploid mutants	—	—	0	0	0	0
Agar, distilled-water						
Original number	—	—	10	20	10	20
Survivors	—	—	10	20	5	13
Polyploids	—	—	0	1	0	0
True-breeding diploid mutants	—	—	0	0	0	0

* 5 × major minerals, 1 × minor elements, 2 per cent sucrose and 0·05 p.p.m. indole-3-acetic acid (ref. 12).

original tissues, is delicate and subject to many factors difficult to control.

The true-breeding diploid mutants which arose after infra-red illumination were similar to those obtained previously from treated seedlings grown in an unshaded greenhouse. Both groups exhibited obvious changes in height, leaf, midrib, panicle, glumes, awns and seed colour, and bred true immediately. These results provide a clue to the variability in occurrence of mutants in greenhouse experiments since light conditions change with the amount of sunshine. They are particularly significant since it is indicated that the phenomenon of the induction of true-breeding mutants can be produced under laboratory conditions. There are therefore external conditions such as light, medium and temperature which determine the occurrence of this phenomenon as well as internal conditions determined by the genotype as indicated by Atkinson *et al.*[2].

Induction of true-breeding mutant types by colchicine treatment of germinating seedlings in the greenhouse has been used with great success in the sorghum-breeding programme at South Dakota State College both to secure new variability and to obtain fixed genotypes immediately. The significance of this phenomenon for currently held theories regarding the behaviour of chromosomes within somatic tissues would seem to be far-reaching, particularly in our understanding of growth processes and, perhaps, of the origin of abnormal growths such as cancer.

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Changes in Amounts of Organic Acids in Citrus Leaves during Periods of Cold Storage

Storage of certain plant products at temperatures below 15° C. but above freezing can cause severe injury to their tissues. As one mechanism to explain this, it has been suggested that cold temperatures could cause changes in the rates of metabolic reactions which would result in an increase or decrease in amounts of metabolic intermediates[1]. Such changes, when excessive, could directly or indirectly damage the plant cells.

Storage at cold temperatures has been shown to cause increases in the respiratory rate of citrus fruit[2], leaves (Eaks, Irving L., personal communication, 1960), and other plant materials[3,4] both before and after the breaking point for the onset of injury. The earliest measured response of sweet potatoes to the chilling temperatures was an accelerated respiratory rate[4], even though at this time no injury had resulted.

Biochemical studies on sweet potatoes indicated that changes in mitochondrial activity could not explain the increased respiratory rate of tissues which had been stored at low temperatures[5]. There is a possibility that changes in amounts of organic acids caused by the periods of cold storage could explain such respiratory increases. The amounts of a number of organic acids in citrus leaves were determined, therefore, to see if any changes occurred and if these changes were associated with cold injury.

Three lemon plants (Lisbon variety, 3 months old) were placed in a darkened chamber at 1° C. An identical number of plants were introduced into darkened chambers at 10° C. and 20° C. A continuous stream of air, saturated with water vapour, was passed through each chamber so that one exchange of air occurred approximately every 15 min. After a predetermined storage period the plants were removed. The third fully expanded leaf from the growing point was removed from each plant. The plants were then placed in a greenhouse, and after 48 hr. the leaf damage resulting from the cold-temperature storage on the unexcised leaves was recorded. Each leaf which was removed was weighed and ground in a pestle and mortar with quartz sand and 3·0 ml. of distilled water. After centrifugation, one aliquot of this solution was titrated to a phenolphthalein end-point with standard sodium hydroxide. The results obtained from this titration were used to determine the total acidity present. Another measured aliquot (usually 1·5 ml.) was mixed with 0·05 ml. of 36 *N* sulphuric acid and 1·5 gm. of silicic acid. The free-flowing powder was quantitatively transferred to a previously prepared silica-gel column. The method of Bulen *et al.*[6] was used for the determination of the acids present. Each determination, therefore, gave the acids present in a single leaf. This procedure was repeated on identical groups of plants stored for varying periods of time at the different temperatures.

The results in Table 1 indicate that cold storage caused as much as a 140 per cent increase in amount

Table 1. Changes resulting from Cold Temperature Storage in Amounts of Organic Acids in Citrus Leaves*

Organic acid	Normal level	Change due to cold storage	
	2 weeks at 20° C. μ equiv./gm. of leaf	2 weeks at 1° C. $\Delta\mu$ equiv./gm.	2 weeks at 10° C. $\Delta\mu$ equiv./gm.
Unknown	23	− 3	− 3
Acetic	4	− 2	0
Fumaric and formic	48	− 7	− 7
Succinic	5	+ 4	+ 6
Malonic	6	+ 1	+ 2
Oxalic	81	−13	−17
Glycolic	82	−25†	−19
Malic	59	+62†	+83†
Citric	280	−88†	−98†
*Iso*citric	73	+14	+ 8

* Each value is the average obtained from six different leaves. Gain of acid over 20° control is indicated by plus values, loss by negative values.

† Significantly different from the amount of the same acid found in the 20° C. sample at the 5 per cent probability-level.

of malic acid in the leaf tissue and a 35 per cent decrease in amount of citric acid. In one case not shown there was a 170 per cent increase in malic acid and a 77 per cent decrease in citric acid. Similar results were obtained in all the experiments conducted. It should be noted that the greatest part of the changes produced by the cold storage occurred between 20° C. and 10° C.

A comparison of the total free acids present in the leaf tissue stored at the lower temperature with those at 20° C. revealed that essentially no significant change had occurred even though malic acid and possibly *iso*citric acid were accumulated.

These results suggest that the ratio of the individual acids to each other was important in the development of cold injury. It is not inconceivable that the accumulation of malic acid and loss of citric acid was in some direct way related to the stimulation of respiration which has been reported and perhaps to the primary damaging reactions producing the injury.

In this type of work it is important to differentiate between those changes which are the result of the death of the cells and those primary changes which cause the death of the cells. Since a redistribution of organic acids occurred both before and after the breaking point for the onset of leaf injury, the organic acid changes reported here could have been closely associated with the primary cause of cold-temperature injury.

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Morphological Reactions of Germinating Seeds as Criteria for the Plant Growth Regulating Activity of Auxin-Type Chemicals

Studying the plant growth regulating effects of more than one hundred chemicals, we directed our attention to the following problems, closely related to the mode of action of auxins: (1) Is there only one, common, basic (auxin-) reaction, underlying the diversity of 'auxin-like' growth effects? (2) Do higher plant species differ with regard to their relative sensitivity towards different auxins? (3) Is the physiological activity of potential auxin precursors to be simply explained by the conversion of the inactive precursor to the active auxin? (4) How far can species differences in the enzymatic conversion of auxin precursor to auxin explain the differences between their sensitivity to the application of auxin precursors? None of these questions has been so far answered[1–6].

With the above considerations in mind, our attention was directed to the wide range of different abnormalities in seedling development, caused by treating germinating seeds with 2,4-dichlorophenoxy acetic acid. The gross morphological effects of this compound were found to consist mainly of inhibition of growth in length on one hand, and stimulation of growth by abnormal cell proliferation

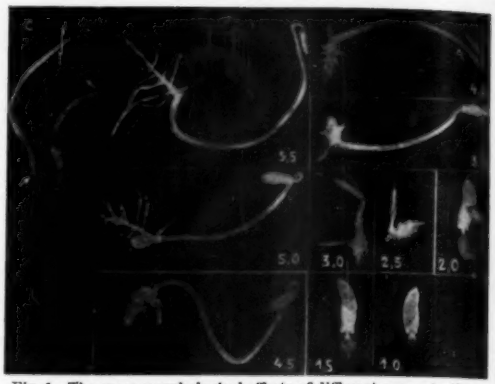

Fig. 1. The gross morphological effects of different concentrations of 2,4-dichlorophenoxy acetic acid on 6-days-old cucumber seedlings. *C*, untreated control, 5·5 to 1·0; the negative logarithm of the 2,4-dichlorophenoxy acetic acid concentration, with 1·0 equal to 1,000 p.p.m.

on the other hand, in the different tissues of the seedlings. The development of the diverse growth effects has shown strikingly high correlation. By comparing the gross morphological effects on cucumber seedlings of an unknown concentration of 2,4-dichlorophenoxy acetic acid to a series of reference standards, the logarithm of the concentration in the experimental Petri dish was found to be determinable within the concentration-range 0·03–1,000 p.p.m. with an accuracy of $\pm$ 0·25 (Fig. 1). Determination of concentrations of 2,4-dichlorophenoxy acetic acid was found to be possible using the same method with seedlings of any other species, although the great sensitivity obtained with cucumber seedlings could be achieved with other species generally only in a narrower range of concentrations of 2,4-dichlorophenoxy acetic acid.

The method, as applied by us in typical experiments, might briefly be described as follows: Three disks of filter paper were placed in Petri dishes and moistened with aqueous solutions of 0·1, 1, 10, 100, and 1,000 p.p.m., respectively, of the substance to be studied. Dry seeds of 23 species of crop plants were placed in a series of dishes (20 seeds of one species per dish, giving the above series of concentrations with every species), and incubated at 24° C. in the dark. The effects were evaluated on the sixth day, by comparing the morphological effects of every concentration with photographs (supplemented by detailed morphological descriptions) of the effects of a comparable series of concentrations of the reference substance(s) on the same species. Activity of a given concentration was expressed by that concentration of the reference substance which proved to be equally effective. In case the equal effectivity at any concentration of the reference substance seemed to be doubtful (due, for example, to a changed correlation between some of the observed growth effects) the disagreement with the reference substance was described and the seedlings photographed. Experiments were repeated at least three times; the results were found to be highly reproducible, in different seasons, and with seeds harvested in different years.

Our test as described above is opposed to the accepted auxin tests, in which statistically evaluated exact measurements of but one aspect (preferably growth in length) of the observable effects are involved while the others are neglected. The overall morphological effect is considered by us as a whole instead,

and used for the determination of equal effectivity with the standards. Fig. 1, nevertheless, illustrates convincingly that the evaluation of the results of the described 'phototest', within the limits of sensitivity given above, is free of subjective errors, and that the sensitivity of the method is comparable to any other biological auxin test. The visually perceptible great sensitivity of germinating seeds to different concentrations of the same auxin-type chemical is caused by strict correlations existing among a great variety of induced growth phenomena which, as a whole, are unmistakably characteristic for a narrow range of concentrations of the substance given. Differences, on the other hand, in the correlations between the observed growth effects, induced by different auxin-type substances, might yield much useful information about problems 1 and 3. In addition, the method presented is a laboratory test, highly reproducible, and reducing the importance of such secondary factors as uptake and transport, for studying possible differences in the sensitivity of different species to auxins as well as to auxin precursors. These characteristics of the method enabled us to draw some tentative conclusions concerning the problems summarized in the introduction, to be described in detail in further communications under preparation.

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Transduction in Actinomycetes

Genetic transduction has been demonstrated in a limited number of bacterial species, such as *Salmonella*, *Escherichia coli*, *Shigella* and *Pseudomonas aeruginosa*[1-4].

As regards Actinomycetes, we[5] have shown that the donor culture on which the actinophage developed determined the pattern of the recipient variation, induced by this actinophage. The ability of actinophage to transfer the prototrophic property from the wind-type strain to the auxotrophic one was also shown. Later, we attempted to obtain prototrophic colonies from an auxotrophic strain, treated with an actinophage, grown on another auxotrophic strain. In this case it was necessary that the donor auxotroph should differ in its nutrient requirements from the recipient auxotroph.

In our experiments, auxotrophic strains No. 2 (*Cys⁻His⁺*), No. 74 (*Met⁻His⁺*), and No. 80 (*Met⁺His⁻*), obtained after the treatment of *Act. olivaceus* strain *N*-6 with X-rays, were used. The transduction was carried out with a temperate phage No. 1. Three different combinations of the above auxotrophs were used. In the first combination, strain *His⁺Met⁻* (74) was used as the donor and strain *His⁻Met⁺* (80) as the recipient. Strain *His⁻Met⁺* (80), treated with a phage, grown on the same strain, and the culture of strain *His⁻Met⁺* (80), not treated with phage, were used as the controls.

In the second combination, strain *His⁻Met⁺* (80) was used as the donor and strain *Met⁻His⁺* (74) as the recipient.

In the third combination strain *Cys⁺His⁻* (80) was used as the donor and strain *Cys⁻His⁺* (2) as the recipient. The controls in the second and the third combinations was carried out in the same manner as in the first combination.

When corresponding phagolysates were plated on the minimal medium, it was observed that combinations *His⁺Met⁻* (74) × *His⁻Met⁺* (80), *His⁻Met⁺* (80) × *His⁺Met⁻* (74) and *His⁻Cys⁺* (80) × *His⁺Cys⁻* (2) very rarely produced prototrophic colonies similar to the wild-type colony (approximately 0·1 per cent). At the same time many small, compact and asporogenic colonies were detected on the Petri dishes. Such colonies were studied by transferring single isolates to the minimal agarized medium in tubes. The majority of them appeared to be auxotrophic with nutrient deficiency of the recipient. In addition, prototrophic colonies, characterized by distinct sporulation when grown on the minimal medium, were observed among them.

In the control combinations *His⁻Met⁺* (80) × *His⁻Met⁺* (80), *His⁺Met⁻* (74) × *His⁺Met⁻* (74), and *His⁺Cys⁻* (2) × *His⁺Cys⁻* (2) small asporogenic

Table 1. Emergence of Prototrophs from Auxotrophs, treated with Actinophage, grown on Auxotrophs differing by their Nutrient Requirements from the Recipient

		Donor	Recipient	No. of colonies studied	Prototrophs isolated	
					Absolute No.	Per cent
Combination No. 1	Experiment	*His⁺Met⁻* (74)	*His⁻Met⁺* (80)	388	31	8·0
	Control No. 1	*His⁻Met⁺* (80)	*His⁻Met⁺* (80)	365	0	0·0
	Control No. 2	No donor	*His⁻Met⁺* (80)	583,000	0	0·0
Combination No. 2	Experiment	*His⁻Met⁺* (80)	*His⁺Met⁻* (74)	292	18	6·1
	Control No. 1	*His⁺Met⁻* (74)	*His⁺Met⁻* (74)	290	0	0·0
	Control No. 2	No donor	*His⁺Met⁻* (74)	345,000	0	0·0
Combination No. 3	Experiment	*Cys⁺His⁻* (80)	*Cys⁻His⁺* (2)	212	12	5·6
	Control No. 1	*Cys⁻His⁺* (2)	*Cys⁻His⁺* (2)	188	0	0·0
	Control No. 2	No donor	*Cys⁻His⁺* (2)	143,000	0	0·0

Table 2. Platings of Prototrophic Colonies, grown as a Result of Transduction

Plating of prototrophic colonies grown from the following combinations	Colony type (per cent)			
	Prototrophic colonies	Recipient type colonies	Donor type colonies	Colonies with double nutrient deficiency
His⁺Met⁻ (74) × *His⁻Met⁺* (80)	21·4	42·8	23·8	11·9
His⁻Met⁺ (80) × *His⁺Met⁻* (74)	4·0	14·0	66·0	16·0
Cys⁺His⁻ (80) × *Cys⁻His⁺* (2)	18·9	20·7	46·6	13·8

colonies were also observed. The analysis of these colonies did not reveal any prototroph among them. All these colonies appeared to be auxotrophs of the recipient type. No prototrophic colonies were detected among the many colonies obtained from auxotrophs No. 2, No. 74 and No. 80, not treated with actinophage.

The results of these experiments are presented in Table 1.

Two types of prototrophic colonies were shown to emerge from the platings of phagolysates. The first type, observed in all three combinations, formed only prototrophic colonies. Examination of the subsequent generations of these prototrophs showed the stability of the prototrophic property. The second type of the prototrophs, also observed in all the combinations studied, segregated out four colony types, that is, prototrophic colonies, auxotrophic colonies with nutrient deficiency of the donor, auxotrophic colonies of the recipient type and auxotrophic colonies with double nutrient deficiency, that is, with nutrient deficiency of both the donor and the recipient (Table 2). The subsequent generations of the four variant types isolated from the platings of the prototrophic colonies were studied. Some variants continued to segregate out colonies of the four types, others segregated out only two or one type of the colonies. However, after one or two transfers, non-segregating and stable lines of all four types were obtained.

How can we explain the segregation of all these forms out of prototrophic colonies, obtained as a result of transduction? If the prototrophs obtained are considered as hybrids, then the segregation of auxotrophs with nutrient requirements of the recipient is the segregation of the parent forms, while the segregation of auxotrophs belonging to the donor type, auxotrophs with double nutrient requirements, and prototrophs appearing stable through further generations are the result of recombinations similar to those induced by transduction in bacteria[6–8]. As for Actinomycetes, it is likely that a definite region of the chromosome appears to be in the 'diploid' state. The fact that on subsequent transfers the variants studied continue to segregate colonies with different nutrient deficiencies may be explained either by presence of different nuclei in the spores, or persistence of the nuclear 'diploid' state through several cell generations. It should also be pointed out that segregation of the donor-type auxotrophs and auxotrophs with double nutrient deficiency out of the prototrophic colonies may be the result of simultaneous transference by the actinophage of two factors, the normal allele of the biochemical deficiency of the recipient and the gene of the biochemical deficiency of the donor.

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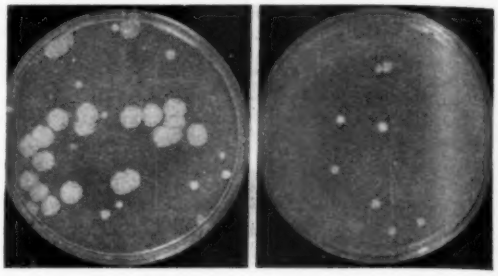
Transformation of a Strain of *Rhizobium lupini*

Transfer of Cysteine-independence. Strain *H*–13, which is a cysteine-dependent mutant of the prototroph *Rhizobium lupini* strain *H*, developed cysteine-independent colonies on treatment with the deoxyribonucleic acid of strain *H* (Fig. 1).



a *b*

Fig. 1. (*a*) Transformed cysteine-independent colonies on minimal agar; (*b*) untreated control.

The small colonies are altered small-step reversions to prototrophy. 10^7 plated cells

The deoxyribonucleic acid was prepared by lysis with sodium deoxycholate (1 per cent) at 55° C. for 10–15 min., followed by deproteinization by Sevag's method and precipitation by 3 vol. ethanol. The transformation was accomplished in a basal salt medium containing cysteine and glucose, on cells pre-incubated for 24 hr.

Fig. 2 shows a typical experiment. In general, I varied the time of addition and action of deoxyribonucleic acid, its concentration, and also the concentration of the cells and the growth-limit, the latter by decreasing the concentration of cysteine.

The following observations were made concerning the mechanism of transformation: (1) at least three

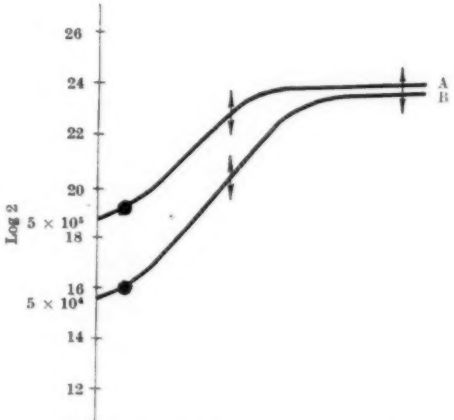


Fig. 2. ●, Time of addition of deoxyribonucleic acid (0·15 μgm./ml.); ↕, time of plating on minimal agar.

Number of transformed colonies: (*A*) plating after 10 hr., 23; 24 hr., 86. (*B*) plating after 10 hr., 15; 24 hr., 24

Fig. 3. From left to right: nodule formation of *H*–13 after one transformation; *H*–13 after two transformations; *M*–32 (control). Plants 4 weeks old

cell divisions are necessary to bring about transformation; (2) the phenotypic expression of transformed cells is preceded by a long transformational lag, during which there is apparently no need for cell division and the transformed character is not yet multiplying.

In consequence of the rather low frequency of transformants—generally the numbers attained did not exceed those given in Fig. 2—the system was not appropriate for more detailed investigations of the mechanism. Probably it is the mucous consistency of strain *H*–13 which opposes the penetration of deoxyribonucleic acid; although it is possible that the medium employed may not have been optimal. Experiments now in progress with rough strains rather point to the first assumption.

Change of Host-specificity. It was proved by Nutman[1] that the relation of *Rhizobium* to the host plant is genetically determined by the plant. On the other hand, interspecific transformations carried out with several species of *Rhizobium*[2] show that the host specificity also is genetically controlled by the bacteria.

In the following experiments the cysteine-dependent *Rh. lupini* (strain *H*–13) was transformed by the deoxyribonucleic acid of an *Rh. meliloti* strain (*M*–32). Lucerne plants inoculated *in vitro* with M_{32} form root-nodules on 95–100 per cent of the plants, whereas lucerne plants inoculated with *H*–13 form no nodules at all.

Preparation of M_{32} deoxyribonucleic acid and transformation of strain *H*–13 were carried out as described above.

In a series of plants inoculated with deoxyribonucleic acid-treated *H*–13, out of 120 plants 14 (11·7 per cent) formed nodules. Generally these were atypical structures developing late; only three plants formed rather typical nodules of greater size. Nitrogen fixation did not occur anywhere. In some series inoculated with single colonies isolated from these nodules, a somewhat higher number of mostly belated ineffective nodules were formed. The percentage yield did not change when cells of isolated colonies were newly transformed with the deoxyribonucleic acid of M_{32}; however, one part of the nodules formed developed at the same time as in the controls inoculated with M_{32} and proved to be typical and later to be effective (see Fig. 3).

These observations suggest that two or more successive distinct transformation types are needed to produce the new host-specificity.

H–13 exhibited in an intraspecific system a low transformation frequency (see above), so in this interspecific combination we suppose the frequency to be essentially lower still, and the changed character as being detected only by the strong selective power of nodule formation.

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CYTOLOGY

Mammalian Cell Chromosome Counts: a Simple Method for making Preparations

For those who work with small mammals, it is sometimes desirable to determine the chromosome complement in cells of particular individuals. Until recently, the most reliable technique for chromosome number determinations depended on the reasonably high mitotic rate and other desirable properties of the seminiferous tubules (for example, Matthey[1]). The difficulty with those techniques is that they do not permit the assessment of chromosome numbers in females, or in males apart from during the breeding season. Beatty[2] described a method of preparing corneal epithelial cells for chromosome counts, which overcame the shortcomings of relying on testicular cells, but many of the metaphase plates were not adequately spread. As a consequence, chromosome counts of only 20 cells from a total of 445 could be listed as exact counts. More recently, Ford *et al.*[3], and many other workers, have described very elegant techniques for mammalian chromosome counts, employing short-time culture of cells from a variety of tissues, primarily bone marrow. The primary difficulty with these techniques is the fact that very few laboratories have the equipment or personnel necessary for the carrying out of tissue culture. Another difficulty is the apparently large number of cells which possess chromosome numbers different from the diploid number. One cannot be sure if this heteroploidy is present in the tissue in the live animals or arises as a result of the extensive preparatory technique. This communication sets forth a relatively simple method for preparing corneal epithelium cells for reliable chromosome counts.

The animal, the cells of which are to be examined, is injected intraperitoneally with 0·01 ml. of 0·04 per cent aqueous colchicine solution/gm. of body-weight. After 3–4 hr. the animal is killed, the eyes are cut out and placed in 0·3 per cent sodium chloride at 37° C. for ½ hr. Fixation takes place in aceto-carmine overnight. Pieces of the epithelial layer are

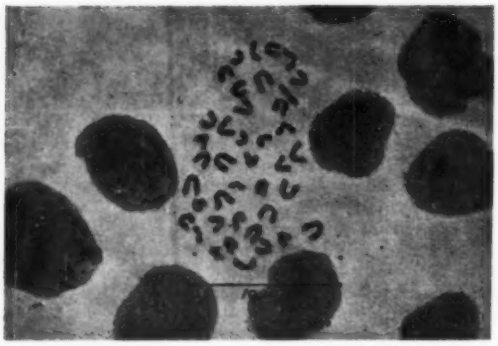

Fig. 1. Metaphase chromosomes of male *Mus musculus*

Fig. 2. Metaphase chromosomes of *Apodemus sylvaticus*

scraped from the cornea into a drop of aceto-carmine on an albuminized slide. The drop is then covered with a piece of 'Cellophane', a ¾-in. square cover-slip and filter paper, and the tissue is squashed in a press, delivering a pressure of about 40 kgm./sq. cm. of cover-slip (see Beatty[2] for details of the press). The 'Cellophane' is removed by letting the slide stand in tap water for about 5 min. Slides are then stained by the standard Feulgen procedure. Hydrolysis is for 10 min. in *N* hydrochloric acid at 60° C.

Preparations made this way from *Mus musculus*, *Apodemus sylvaticus*, and *Clethrionomys* sp. have invariably yielded many clear, well-spread metaphase plates, excellently suited to chromosome counting. As many as 30 metaphase plates suitable for counting are available from the epithelium of one mouse cornea. Typical plates are shown in Fig. 1 for the mouse and Fig. 2 for *Apodemus*.

In order to assess the efficacy of this method, the chromosomes of 5 cells from each of 10 male and 10 female mice were counted. The first 5 cells to appear suitable during examination with a low-power microscope objective were counted. The results are shown in Table 1. Of the 100 cells counted, an exact count was possible in 77, that is, there was no overlapping or crowding of the chromosomes so that no doubt existed about the precision of the count. Of these 77 cells, all but one contained 40 chromosomes. This one contained only 36. In 23 cells there were one or two places where mistakes might have occurred in counting, and these were therefore

Table 1. Numbers of Cells containing Various Chromosome Numbers

	Chromosome count					
	36	40	40 ± 1	40 ± 2	44 ± 2	
Males		35	11	4		
Females	1	41	5	2	1	
Total	1	76	16	6	1	100

not scored as exact counts. Nevertheless, in 22 of these 23 cells, the 'most likely' number of chromosomes was 40. In one cell the 'most likely' number was 44. If one combines the exact counts and the 'most likely number' counts, it is seen that 98 of 100 cells have chromosome numbers compatible with the number 40. This confirms the observation of Beatty that the corneal epithelium exhibits extremely high constancy in regard to chromosome number. The apparent advantage of the method described here over that described by Beatty is in the much greater proportion of cells the chromosome number of which could be exactly determined. When compared to the techniques involving tissue culture, my method enjoys the advantages of simplicity and constancy of chromosome number, but suffers the disadvantage that the animal must be killed. Because the corneal epithelium is a surface tissue and because both chromatids of each chromosome are clearly visible in the cells prepared by this technique, it would appear that this might be an excellent means of ascertaining the extent of chromosome breakage in the living animals which is caused by ionizing radiation or other agents.

This work was done during the tenure of a Nato postdoctoral fellowship. I would like to express gratitude to Prof. C. H. Waddington for permission to work at the Institute of Animal Genetics and for providing space and facilities; to Dr. J. G. Campbell for taking the photographs; and to Dr. R. A. Beatty for continual helpful advice, and for collecting the wild rodents.

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Structural Changes in Mitochondria of *Acanthamoeba* at Encystation

For some time now the mitochondria have been ascribed a role in cellular respiration and more recently changes in intracellular ion concentration and tonicity have been shown to have marked effects on both mitochondrial volume and respiratory activity[1]. This communication reports changes in the structure of the mitochondria of a small amœba occurring at a time in the life-cycle when the intracellular environment is undergoing profound changes and respiratory activity is reduced to a minimum, namely, at encystation.

A clone strain of a soil amœba, *Acanthamoeba* sp., was isolated in this laboratory and maintained in monoxenic culture with *Aerobacter aerogenes* on 0·2 per cent peptone agar plates. The organisms were washed off the plates with distilled water before

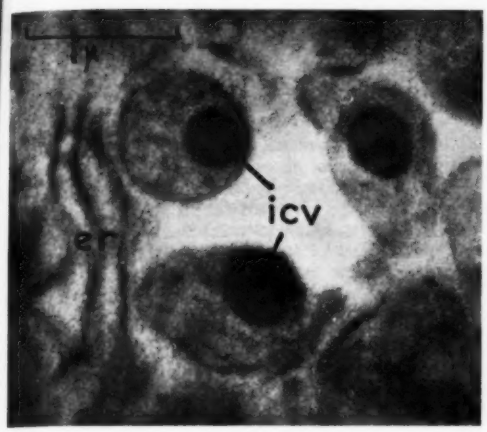
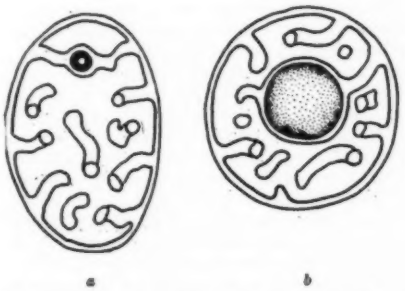


Fig. 1. Part of section of cyst showing three mitochondria with intra-cristal vesicles (*icv*), also tubules of endoplasmic reticulum (*er*)

fixing in permanganate[2] at *p*H 7·2 for 2 hr. at 4° C. Dehydration was in ethanol, 'staining' in 1 per cent phosphotungstic acid in absolute ethanol and embedding in 'Araldite'. Silver or gold sections were cut on the Porter-Blum microtome, mounted on carbon films and examined in the Siemen's Elmiscope 1*b* electron microscope.

The mitochondria of trophic amœbæ are usually oval in shape and measure 0·5–1·5μ × 0·5–1·0μ, but the shape is variable, and cup-shaped and even branched mitochondria have been seen in sections. Their internal structure resembles that of other free-living Protozoa. Each is surrounded by a double membrane: from the inner membrane tubular cristæ project into the mitochondrial lumen and in some cases they can be seen to traverse it. Often small spherical inclusions can be seen inside the cristæ. These have a diameter of 500–1000 Å. and if not completely electron-dense have a thick electron-dense cortex. More than one of these intra-cristal inclusions has never been observed in a mitochondrion.

In the mitochondria of the cyst the intra-cristal inclusions take the form of larger vesicular structures. They have a diameter of 3000–5000 Å. (0·3–0·5μ) and they are more opaque to the electron beam than is the surrounding mitochondrial matrix (Fig. 1). Electron-dense granules, irregular in size (50–300 Å.) and shape, lie immediately beneath the bounding membrane of the vesicle. The mitochondria of the cyst are usually spherical, 0·5–1·0μ in diameter. In some sections of cysts the outer membrane of a mitochondrion appears to be continuous with the membrane of a tubule of the endoplasmic reticulum.



a *b*

Fig. 2. Diagrams of mitochondria of amœba (*a*) and cyst (*b*) seen in section to show intra-cristal inclusions

It appears that at encystation in *Acanthamoeba* the intra-cristal bodies of the mitochondria swell to become vesicles which occupy a considerable part of the mitochondrial lumen. This change is represented in diagrammatic form in Fig. 2. One effect of this swelling is presumably to reduce the volume of the mitochondrial lumen. In a recent experimental study of the osmotic properties of isolated *Acanthamoeba* mitochondria, Klein and Neff[1] found that respiratory-rate was proportional to mitochondrial volume and that both were decreased by raising the tonicity of the surrounding medium. They suggested, however, that mitochondrial volume changes were under most conditions not primarily due to osmotic effects but rather to colloid swelling and shrinking phenomena. The effects of experimental changes in tonicity on the intra-cristal inclusions of *Acanthamoeba* have not yet been studied. A fuller report of work on the fine structure of this and other *limax* amœbæ will be published elsewhere.

I wish to thank Prof. J. Z. Young for facilities in his electron microscope laboratory and Dr. J. D. Robertson for his interest and advice.

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BACTERIOLOGY

Heterogeneity of Cultures of *Escherichia coli B/r*

A LARGE amount of the recent literature in radiation bacteriology and allied fields is concerned with the detailed behaviour of cultures labelled *Escherichia coli B* and *Escherichia coli B/r*. *E. coli B* is a bacterial strain that has been maintained for many years, mainly in laboratories concerned with bacteriophage synthesis and behaviour. It is characterized by its unusual sensitivity to several deleterious agents, including the *T* series of *coli* bacteriophages. *E. coli B/r* is one of a large group of mutants selected from *E. coli B* after irradiation with ultra-violet light. Witkin carefully defined *B/r* and distinguished it from *B* and other ultra-violet-selected mutants of *B*[1,2]. *E. coli B/r* was characterized by, among other things, its enhanced resistance to ultra-violet light, X-rays, penicillin, and sodium sulphathiazole. Furthermore, the snake-like forms found with very high frequency in *B* cultures irradiated with ultra-violet were found only occasionally in *B/r*.

A survey of the literature and our own experimental experience suggest that the various cultures labelled *E. coli B/r* are not identical. For example, Morse and Carter[3] claimed that *B/r* had 3–4 times more deoxyribonucleic acid per cell than *B*, whereas Harold and Ziporin[4] claimed that there was no difference. Preliminary results obtained in this Laboratory suggested that the viable cell titres and X-ray sensitivities of two *B/r* cultures being used routinely were not identical. The experiments

reported here were designed to compare, under standardized conditions, various aspects of *B/r* cultures obtained from different sources.

E. coli B ORNL and *E. coli B/r ORNL* were obtained from the Carnegie Institution, Cold Spring Harbor, about 12 years ago, and have been stocked on refrigerated agar-slants at Oak Ridge National Laboratory since then. They have been transferred at approximately 6-month intervals. These are the cultures most frequently used for work reported from this Laboratory. *E. coli B CSH* and *E. coli B/r CSH* were received from the Carnegie Institution about 3 years ago and have been stocked on refrigerated nutrient-agar. *E. coli B/r* Cornell University, *E. coli B* Institut du Radium, and *E. coli B/r* Institut du Radium were received from the institutions indicated and were refrigerated on arrival. All the cultures were transferred, by mass inoculum, at the beginning of this series of experiments to a medium (total volume, 1 l.) composed of 10 gm. of 'Bacto-Peptone', 1 gm. of dextrose, 1 gm. of yeast extract, 7·6 gm. of dipotassium hydrogen phosphate, 4·5 gm. of potassium dihydrogen phosphate, and 20 gm. of agar. These slants were used as inocula for all experiments.

Preparation of cells and irradiation techniques with X-rays and ultra-violet light are described elsewhere[5]. Determinations of snake-formation and penicillin sensitivity were carried out essentially as described by Witkin[2]. Optical density was determined with a 'Lumetron' colorimeter with a 650-mμ filter.

Fig. 1 shows that the *B/r* cultures are heterogeneous with regard to X-ray sensitivity. Three of them

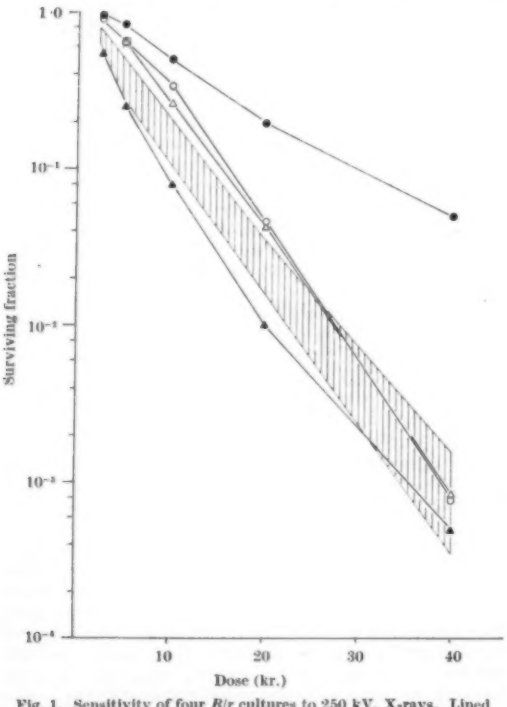

Fig. 1. Sensitivity of four *B/r* cultures to 250 kV. X-rays. Lined area represents range of results obtained with three *B* cultures. ●, *B/r ORNL*; ■, *B/r* Institut du Radium; △, *B/r* Cornell University; and ▲, *B/r CSH*

Table 1. Characteristics of *B* and *B/r* Cultures

Culture	'Snake' formation after 50 ergs of ultra-violet radiation	Final optical density*	Units of penicillin 'G' required for 100 per cent inhibition
B ORNL	+	0·309 ± 0·017	40
B CSH	+	0·303 ± 0·023	40
B Institut du Radium	+	0·297 ± 0·016	40
B/r ORNL	−	0·332 ± 0·034	60
B/r CSH	−	0·243 ± 0·035	120
B/r Institut du Radium	−	0·218 ± 0·030	120
B/r Cornell University	−	0·179 ± 0·025	60

* Based on six determinations per value. One *S.E.* is indicated.

are not strikingly different in sensitivity from the group of three *B* cultures, which form a relatively homogeneous group. To test whether these three *B/r* cultures had 'reverted' to *B*, several criteria were used. Table 1 shows that none of the *B/r* cultures forms 'snakes' after exposure to low doses of ultra-violet light, whereas all the true *B* cultures do. It also shows that the *B/r* cultures are a heterogeneous group with respect to final optical density and that optical density is not correlated with radiation sensitivity. Table 1 also shows the concentration of penicillin required to achieve 100 per cent inhibition of growth as determined by final optical density.

We attempted to determine the sensitivity to ultra-violet radiation of the *B* and *B/r ORNL* and *B* and *B/r CSH* pairs. The results are confounded by a disturbing amount of variation observed in absolute sensitivities from experiment to experiment, even though elaborate precautions were taken to avoid photoreactivation, heat restoration, and other known variables. Nevertheless, it is fair to make certain conclusions based on six independent experiments done for each pair of cultures. Both the *ORNL B/r* and the *CSH B/r* cultures show sigmoid survival curves to ultra-violet radiation. They are each somewhat more resistant than the corresponding *B* cultures, which show more nearly exponential survival. The difference in sensitivity in any one experiment between a *B* and its corresponding *B/r* is never as large as that reported by Witkin[2].

The results reported here support the contention that cultures labelled *E. coli B/r* being used in different laboratories form a genotypically and phenotypically heterogeneous group. *E. coli B* cultures are relatively homogeneous.

Cultures of the strain *B/r* differ from each other in their response to X-irradiation, and their physiological capabilities under standardized conditions. Three of the four cultures have an X-ray sensitivity characteristic of *B* cultures, but cannot be classified as 'revertants' since they do not form the 'snakes' characteristic of *B* cultures. Two of these three, although they have strikingly similar X-ray sensitivities, can usually be distinguished from each other on the basis of final optical density and sensitivity to penicillin.

The results obtained with ultra-violet irradiation (2537 Å.), although variable and not done under conditions identical to those used by Witkin[2], suggest that none of the *B/r* cultures is as strikingly resistant to ultra-violet light as the original *B/r*.

Since the current trend in much radiation bacteriology research is to relate radiation sensitivity to the detailed metabolic mechanisms of cells and to

generalize results from one laboratory to another, our results indicated the need for a note of caution. This is particularly true if one also considers that any one of these cultures may show several forms of sensitivities to X-rays and ultra-violet light, depending on the growth medium and other factors[5]. The cultures used in this work were not pre-selected for heterogeneity. They were chosen because they were readily available. It is likely that other groups of *B/r* cultures from other laboratories would be equally heterogeneous. Greater attention to the techniques of maintaining cultures and periodic checking of culture characteristics may allow a more meaningful correlation of the results obtained in different laboratories. We suggest that the designation *E. coli B/r* be reserved only for cultures having all the characteristics originally observed by Witkin.

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Chitin Breakdown of Rhizosphere Bacteria

BENECKE[1] was the first to isolate chitinovorous bacteria from Kiel harbour. Since then much work has been done on microbiological breakdown of chitin. Micro-organisms producing chitinase have been observed in fresh and salt waters, in various kinds of soils, in plants and animal bodies, both living and decomposing. It has been reported that pathogenic micro-organisms also break down chitin.

I have studied whether bacteria living in the rhizosphere of superior plants are capable of attacking chitin.

For this purpose chitin has been prepared from the wing-cases of *Melolontha melolontha* L. with the Zechmeister procedure applied also by Gehring[2]. The native chitin obtained in this way was suspended in medium according to Bucherer[3]. The chitin was present in the medium as the sole source of carbon and nitrogen in amounts of 0·1, 0·25, and 0·5 per cent. Dipotassium hydrogen phosphate and magnesium sulphate (0·03 or 0·1 per cent) were added. The solid medium contained 2 per cent washed agar. In all cases the *p*H was 7.

Bacteria were isolated on chitin agar and meat agar plates from the rhizospheres of winter wheat (*Triticum vulgare*), sugar-beet (*Beta vulgaris saccharifera*), and false acacia (*Robinia pseudoacacia*) with Tepper's[4] successive washing method (from the dilution of washed and triturated root). About 20 per cent of the bacterial colonies grown on meat agar, tested on both solid and liquid media, proved to be chitinivorous.

The bacterial colonies grown on chitin agar did not show a great variety of types, but the number of individuals was rather high. Their total reached several hundred thousands per 1 gm. of washed root.

From the chitinivorous rhizosphere bacteria of winter wheat and false acacia a rod-shaped, most frequently occurring, active chitinivorous organism—one from each—was selected. These retained their capacity of breaking down chitin for rather a long time. These bacteria were subjected to detailed examination. In addition to them the capacity of breaking down the chitin of rhizosphere bacteria isolated on non-chitinous media by other workers was also studied: none of the five *Pseudomonas* strains belonging to various serological groups, grown from the rhizosphere of flax by Lovrekovich[5], tested with the method described above, was found to decompose chitin. Out of the sixteen *Bacterium* strains grown from sugar-beet, Gyurkó[6] subjected to detailed physiological examination five strains proved to be chitinivorous and the strains kept on meat agar have preserved this property for more than two years.

I wish to thank my colleagues, L. Lovrekovich and P. Gyurkó, for the strains examined.

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VIROLOGY

Influenza Virus Sialidase

THE sialidase of influenza virus has been investigated quantitatively using the method recently described by Warren[1] for determining free sialic acid in the presence of the compound bound to mucoprotein substrates. For this work, the substrate used was a mucoid derived from the nest-cementing substance of the swiftlet (*Collocalia* sp.). The crude material, available as Chinese 'edible birds' nest', was extracted with water at 60–65° to yield a product which contained 10 per cent acid-hydrolysable sialic acid and which in high titre inhibited the agglutination of chicken erythrocytes by 'indicator' virus. Active virus was sedimented from freshly gathered chorioallantoic fluid by centrifugation at 35,000*g* for 90 min. The virus pellet was re-suspended in water to a volume 1/50–1/100 that of the original fluid, effecting thereby a corresponding increment in hæmagglutinin titre as well as separation of virus from interfering chromogens present in chorioallantoic fluid.

Aliquots of virus (*A*2/Japan/305/57) representing a six-fold concentration of infective chorioallantoic fluid were mixed with substrate in phosphate (*M*/15) buffers, *p*H 4·0–7·8, at 37°, in the proportion 10 μgm. viral nitrogen to 1·4 mgm. substrate. Samples were removed at 10-min. intervals from 0 to 50 min., and were immediately heated to 75° for 10 min., a temperature found to inactivate the virus completely. All samples were either stored frozen or at 4° prior to being analysed simultaneously for sialic acid. Virus alone and solutions of substrate at each *p*H, after incubation and heating to 75° for 10 min., showed no free sialic acid. The most rapid evolution of chromophore due to enzyme occurred at *p*H 5·3 and 6·1. These values probably encompassed the *p*H optimum for this strain, as the enzymatic release of sialic acid at *p*H 4·0, 7·0 and 7·8 was significantly slower (Fig. 1*A*). Closely similar results were obtained with three other strains of virus (*NWS*, *FM*1 and *PR*301) and are therefore not given in

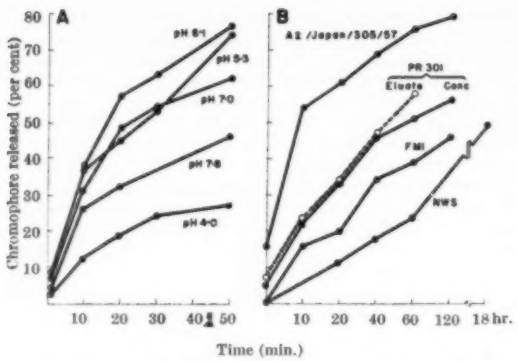

Fig. 1. *A*, Liberation of sialic acid (expressed as percentage of total acid-hydrolysable thiobarbituric acid chromophore) in relation to time, at 37°, *p*H 4·0–7·8. (*A2*/Japan/305/57 concentrated six-fold from chorioallantoic fluid.) *B*, Relative enzymatic potency, at *p*H 5·5, 37°, of four strains (*A2*/Japan/305/57, *PR*301, *FM*1, *NWS*) after concentration and adjustment to the same turbidity

detail. At each *p*H the per cent sialic acid released, expressed as a fraction of total acid-hydrolysable chromophore, approached the same maximum (greater than 80 per cent) after incubation at 37° for more than 2 hr. In acetate buffer (*M*/100) at *p*H 5·5, the sialidase of the *A2* strain of virus was inhibited by copper (*M*/800), but not by nickel, zinc, magnesium or manganese, was fully active in the presence of versene (0·02 per cent), and more active at 37° than at 26°. Specific enzymatic activity was proportional to virus concentration. Receptors in *Collocalia* mucin for several indicator strains of influenza virus were inactivated by treatment with concentrated active virus. N-acetylneuraminic acid was identified chromatographically as the only chromogenic substance liberated by viral enzyme from this substrate.

The activity of *A2*/Japan/305/57 virus was compared with that of *FM*1, *PR*301 and *NWS* viruses. The concentrated viral suspensions were adjusted to the same optical density as measured on a Coleman nephelometer, and assayed at *p*H 5·5 as described above. Under these conditions, the *A2* strain was far more active than either of the other three (Fig. 1*B*), releasing more than 50 per cent of the chromogen in 10 min. As also shown in Fig. 1*B*, the same preparation of concentrated *PR*301 virus was adsorbed to and eluted from chicken erythrocytes with no loss of enzymatic activity.

The *A2* strain of virus was grown in monkey kidney monolayers in 2-oz. prescription bottles. Prior to inoculation, the growth medium was removed, the cells washed and 5 ml. serum-free maintenance solution added (2 parts mixture 199 and 1 part Earle's balanced salt solution). Hæmagglutinin appeared in 3–5 days, followed by gross cytopathic changes. 10 ml. of culture fluid from two bottles of the fourth passage were centrifuged at 40,000*g* for 90 min., the pellets resuspended in 0·1–0·2 ml. water, and assayed for enzyme. More than 80 per cent of the bound sialic acid in samples of *Collocalia* mucin was liberated by this virus preparation after incubation at 37° for 16 hr. Normal culture fluid had no enzymatic activity.

The sialidase activity of an *A2* strain of influenza (Japan/305/57) appeared to be far greater than that of the other strains tested. Even the few seconds necessary to mix virus with substrate was sufficient to permit the liberation of 15 per cent of the thiobarbituric acid chromophore. These results are in general agreement with the findings of Seto *et al.*[2], who concluded that *A2* strains showed greater sialidase activity than any other strains previously studied. These authors state that their *NWS* strain of influenza *A* had no sialidase activity, whereas the *NWS* strain used in the present work showed pronounced enzymatic activity, albeit less than that of the *A1* strains. The reasons for this discrepancy are not apparent and deserve further investigation.

Reliance on turbidity measurements alone as a quantitative measure of virus particle concentration, and therefore as a basis of comparison, is subject to obvious error because of the possible inclusion of varying amounts of chicken tissue particles in each concentrated virus sediment. It is unlikely, however, that either the extent or variation of tissue contamination from one virus preparation to another was great enough to account for the major differences in enzymatic activity between the *A2* strain on one hand and the *A* and *A1* strains on the other. Further comparative investigations are planned with enzyme purified from both egg-grown virus and that produced in monkey kidney cell cultures which appears to be enzymatically just as active.

This work was carried out under the auspices of the Commission on Influenza, Armed Forces Epidemiological Board, and was supported in part by the Office of the Surgeon General, Department of the Army, Washington, D.C., and by grant No. *E*-3168 from the United States Public Health Service.

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A Plaque Technique for the Primary Isolation of Arthropod-borne Viruses

The demonstration that a wide range of different arthropod-borne viruses could produce plaques in monolayer cultures of chick embryo cells[1] raised the possibility that this technique could be used for the primary isolation of viruses in this group. This point was investigated first by the examination in London of material submitted from Uganda, and later during a visit of one of us to the Virus Research Institute, Entebbe.

During an epidemic of O'nyong-nyong fever in Uganda a number of strains of a virus which was classified as a member of the group *A* arthropod-borne viruses[2] was isolated from sera collected from persons during the acute stage of the illness[3]. One such serum, which had yielded virus by the intracerebral inoculation of one-day-old mice, was forwarded to London packed in ice at 0° C. When dilutions of this serum were tested by the plaque technique, approximately 50 plaques were produced in plates inoculated with 0·5 ml. of a 1 : 10 dilution, and 3 and 4 plaques developed in plates infected with serum diluted 1 : 100. The same results were

obtained in a second experiment carried out in London with the same serum sample. Since O'nyong-nyong virus requires a number of serial passages in one-day-old mice before it kills these regularly, the advantages of a direct tissue culture system are obvious.

When this experiment was repeated at Entebbe with another sample from the same batch of serum, once again plaques were produced. However, six other sera collected in the course of the same epidemic which had previously been shown to contain virus failed to produce plaques, although simultaneous tests carried out in one-day-old mice showed that virus was still detectable in four of them by this method. Since these sera had been stored for several months at approximately −60° C. it was felt that fresh material might provide a more useful basis for the comparison of the two techniques. Unfortunately, no fresh material was available from O'nyong-nyong fever patients, but a small outbreak of Rift Valley fever in the vicinity of Entebbe[4] was investigated by both methods.

One acute phase human serum produced more than 100 plaques per 0·5 ml. of a 1 : 10 serum dilution, and 22 plaques per 0·5 ml. of a 1 : 100 dilution. Rift Valley fever virus was isolated from this serum sample by the inoculation of one-day-old mice, the virus titre being $10^{2.5}$ per 0·1 ml. A second human serum also yielded virus by both methods. A mosquito pool suspension from which Rift Valley fever virus had been isolated in mice was retested by both methods after 8 days storage at −20° C. On this occasion no virus was isolated in mice, but one plaque developed in a plate infected with 0·5 ml. of a 1 : 10 dilution of the mosquito suspension. When material from this plaque was inoculated into mice, Rift Valley fever virus was again recovered. The identity of the virus was established by the inhibition of plaques produced by infected mouse brain suspension around a bead containing a known Rift Valley fever immune serum.

These preliminary experiments indicate that virus isolations may be accomplished by the direct use of the plaque technique, but that the method is probably less sensitive than the use of one-day-old mice, though a much larger series would be required to give a better assessment of the comparative sensitivities of the two methods. The single occasion when virus was recovered in tissue culture and not in mice may be explained in terms of the considerably greater volume of material used in the former system ; had an equivalent volume of mosquito suspension been inoculated into further mice, it is probable that virus would have been recovered by that process also.

Although this has not yet been accomplished in practice, a combination of primary isolation in tissue culture, together with plaque inhibition around beads dipped in specific antisera, offers the possibility of virus isolation and identification in a single process.

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SOIL SCIENCE

Negative and Positive Adsorption of Chloride by Kaolinite

Schofield and Samson[1] have indicated that the edge face of kaolinite crystals should, under acid conditions, adsorb one chloride ion for each 33 Å.^{2}. They obtained results which showed that on the acid side of neutrality the positive edge charge of a potassium kaolinite was such that it exceeded the negative adsorption of chloride ions resulting from the repulsion of these ions from the negative cleavage face. Further, these authors noted that for conditions more alkaline than about *p*H 6·5 in 0·005 *M* sodium chloride the clay exhibited a negative adsorption. When Schofield's[2] theory was applied to these results, a surface area of 25 m.^{2}/gm. was obtained and this was lower than the 39 m.^{2}/gm. obtained by low-temperature nitrogen adsorption. The constant negative adsorption for alkaline conditions was interpreted as being due to the disappearance of positive edge charges. Work reported here, however, shows a positive adsorption dependent on concentration under conditions as alkaline as *p*H 10. When allowance is made for this positive adsorption the correct value is obtained for the surface area.

The results reported here were obtained for a kaolinite obtained from the pallid zone of a laterite at Rocky Gully in Western Australia. It is the same material designated as kaolin *S* by Samson and Schofield. The clay (less than 2μ) was washed with *M* potassium chloride containing 10^{-2} hydrochloric acid ; then with water until the chloride ion concentration was less than 10^{-3} *M*. The required amount of base and electrolyte was added. The clay suspension was centrifuged at low speeds and chloride was determined by an electrometric method in the centrifuged clay and the supernatant liquid.

In Fig. 1 the negative adsorption of a potassium kaolinite at *p*H 9 can be seen to be considerably less than that expected on the basis of Schofield's theory. It is interesting to note that the value obtained at 0·01 *M* potassium chloride is in agreement with that obtained by Schofield and Samson. Although the *p*H of the suspension was 9, it was suspected that the low

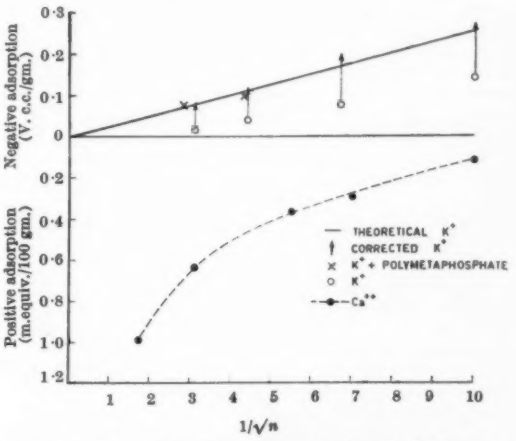

Fig. 1. The negative and positive adsorption of chloride by potassium and calcium kaolinite at *p*H 9. *n*, Concentration in m.equiv. per ml.

Fig. 2. Effect of *p*H on the positive adsorption of chloride by calcium kaolinite

values for the negative adsorption were caused by a concomitant positive adsorption. The kaolinite was treated with sodium polymetaphosphate (6 m.equiv./100 gm. adsorbed) and the results obtained by the negative adsorption of chloride then agreed with the theoretical expectation. Since this was considered only circumstantial evidence for the existence of chloride uptake at *p*H 9, more direct proof was sought. Since the negative adsorption of chloride for a clay saturated with a divalent cation is considerably less than for a monovalent ion, the kaolinite was saturated with calcium and it was found that positive adsorption predominated and also that the chloride adsorption was dependent on concentration. When the potassium kaolinite results were corrected for the amount of positive adsorption for the calcium kaolinite, the arrows in Fig. 1 indicate that the cleavage face is in fact repelling chloride ions in the expected fashion. It is pointed out that since there would be some negative adsorption of the calcium kaolinite this procedure would under-estimate the positive charge and hence the corrections applied to the potassium kaolinite would be slight under-estimates.

In Fig. 2 the effect of *p*H and electrolyte concentration on the adsorption of chloride by a calcium kaolinite is shown. At about *p*H 7 in 0·1 *M* calcium chloride there is a transition from concentration-dependent to concentration-independent chloride adsorption.

The ceiling value of 3 m.equiv./100 gm. attained at about *p*H 3 represents an edge surface area of 6 m.²/gm. and this is 14 per cent of the B.E.T. area for the material. Cashen has reported edge areas of 11 and 19 per cent for Mercks and Peerless kaolin. These were measured by titration of the kaolins with cetyl trimethyl ammonium bromide before and after treatment with pyrophosphate or oxalic acid, both of which would render the edge face negative.

As noted by Schofield and Samson this kaolinite contains a small quantity of iron oxide (< 2 per cent goethite) as impurity but this would only affect the results to a minor extent.

These investigations are continuing and work on the importance of edge faces as the site of phosphate fixation are in progress.

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[1] Schofield, R. K., and Samson, H. R., *Disc. Farad. Soc.*, **18**, 135 (1954).
[2] Cashen, G. H., *Trans. Farad. Soc.*, **55**, 477 (1959).

MATHEMATICS

William Stroud and Quantity Calculus

The convention of representing physical quantities, rather than their measures, by letters is said to have been "devised in the eighties of last century by that versatile genius Prof. William Stroud, of Leeds University"[1]. A succession of teachers of applied mechanics at the Royal Naval College, Greenwich (J. B. Henderson, B. P. Haigh, J. G. Docherty, F. W. Thorne and A. C. Walshaw), and other teachers have always referred to this convention as the 'Stroud system'[2]. It is the main purpose of this communication to present some reasons why this attribution is unsatisfactory and why it would be better to replace it by the term 'quantity calculus' used by E. A. Guggenheim and others[3].

There is no written evidence that William Stroud ever used the conventions of quantity calculus. The following question from one of his examination papers shows that he did not use it in his teaching: "The thermo-electric power of Cu—Pb = $0{\cdot}0124\,(67 + t)$ and for Fe—Pb = $0{\cdot}042\,(357 - t)$. Find the E.M.F. in a Cu−Fe circuit whose junctions are at 100° C. and 200° C."[4].

There is evidence that others were advocating and using quantity calculus before or at the time that William Stroud is said to have been teaching it. Following the publication of J. B. Henderson's account of the 'Stroud system'[1], E. H. Neville[5] immediately pointed out that J. D. Everett[6] had certainly used quantity calculus in 1879, though, I would add, not always in a consistent manner. It is of interest to note that William Stroud was certainly acquainted with J. D. Everett's text-books, because one of the recommended books for the first-year course in physics at the Yorkshire College was Deschanel's "Natural Philosophy", Vol. 1, thirteenth edition, which was translated and edited by J. D. Everett[7]. The first clear expression of the principles of quantity calculus is undoubtedly A. Lodge's very concise presentation of its conventions under the significant title: "The Multiplication and Division of Concrete Quantities"[8].

In view of these historical difficulties, it would appear to be best to speak of 'quantity calculus' rather than of the 'Stroud system'.

I wish to acknowledge the help I have received from Miss D. M. Leak, of the Brotherton Library, University of Leeds; the Directors of Barr and Stroud, Ltd., Glasgow; and Prof. F. W. Thorne, Dr. A. C. Walshaw and Dr. J. G. Docherty.

G. N. Copley

17 Calderstones Avenue,
Liverpool 18.

[1] Henderson, J. B., *Math. Gaz.*, **12**, 99 (1924).
[2] Grundy, R. H., "Symbols for Students" (George Reed, Liverpool, 1943). Jeffreys, H., "Scientific Inference", second ed., 87 (Cambridge Univ. Press, 1957). Thorne, F. W., and Walshaw, A. C., "Engineering Units and the Stroud Convention" (Blackie and Son, London, 1954). Walshaw, A. C., *Bull. Mech. Eng. Educ.*, **15**, 28, 79 (1959).
[3] Guggenheim, E. A., *J. Chem. Educ.*, **35**, 606 (1958). Copley, G. N., *J. Roy. Inst. Chem.*, **83**, 477 (1959).
[4] "The Yorkshire College Leeds Calendar", 1895–6, question 4, p. 275.
[5] Neville, E. H., *Math. Gaz.*, **12**, 442 (1925).
[6] Everett, J. D., "Units and Physical Quantities", second ed. (Macmillan, London, 1879).
[7] "The Yorkshire College Leeds Calendar", 1895–6, p. 95.
[8] Lodge, A., *Nature*, **38**, 281 (1888).

FORTHCOMING EVENTS

(Meetings marked with an asterisk • are open to the public)

Monday, October 17

UNIVERSITY OF LONDON (at Senate House, London, W.C.1), at 5.15 p.m.—Prof. J. Piaget (International Bureau of Education, Geneva): "The Thinking of Young Children".•

UNIVERSITY OF LONDON (at Queen Elizabeth College, 61–67 Campden Hill Road, London, W.8), at 5.30 p.m.—Prof. A. J. Ayer: "Contemporary British Philosophy".•

INSTITUTE OF METALS, LONDON LOCAL SECTION (joint meeting with the INSTITUTE OF METAL FINISHING, at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. C. Williams: "Electroplating Processes and Effect on Fatigue Strength and Embrittlement of the Substrate".

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Dr. Eric Axelson, "Henry the Navigator and the Sea Route to India" (First Eva G. R. Taylor Lecture).

Tuesday, October 18

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. H. Kalmus: "The Biology of Fighting".•

UNIVERSITY OF LONDON (in the Great Hall, Queen Mary College, Mile End Road, London, E.1), at 1.30 p.m.—Sir Vivian Fuchs: "Antarctica Today".•

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. F. Hirzebruch (University of Bonn): "The Rôle of Characteristic Classes in Algebraic Topology".• (Further lectures on October 19 and 20.)

BRITISH ORNITHOLOGISTS' UNION (joint meeting with the BRITISH ORNITHOLOGISTS' CLUB, in the new Lecture Hall of the British Museum (Natural History), Cromwell Road, London, S.W.7), at 6 p.m.—Annual Scientific Meeting. Dr. A. J. Cain: "Tropical Forest and Bird Ecology" (illustrated with slides and a film).

OIL AND COLOUR CHEMISTS' ASSOCIATION, LONDON SECTION (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. R. D. Griminski and Mr. F. M. P. Meredith: "The Lacquering of Aluminium–Magnesium Alloys".

Wednesday, October 19

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. K. Lowe: "Tests of Renal Function".•

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. E. Prentice: "The Stratigraphy of the Upper Carboniferous Rocks of the Rideford Region, North Devon"; Dr. D. C. Knill and Dr. J. L. Knill: "Time Relations Between Folding, Metamorphism and the Emplacement of Granite in Rosguill, Co. Donegal".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Discussion on "Pulverized Fuel Flames", led by Mr. G. G. Thurlow.•

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. E. L. Robinson: "The Developing Engineer" (Chairman's Address).

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Prof. R. Ruggles Gates, F.R.S.: "The Histology of Skin Pigmentation".

CEMENT AND CONCRETE ASSOCIATION (at the Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1), at 6 p.m.—Mr. F. R. Belson: "Lift Slab Design and Construction."

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. C. Edeleanu and Mr. J. B. Cotton: "Anodic Protection". (*A*) "Principles". (*B*) "Practical Application".

BRITISH INSTITUTION OF RADIO ENGINEERS, MEDICAL AND BIOLOGICAL ELECTRONICS AND COMPUTER GROUPS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Symposium on "The Use of Computers in Biological Waveform Analysis".

Thursday, October 20

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. J. H. Callomon: "The Danish East Greenland Expeditions, 1957–58".•

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—October General Meeting.

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. V. P. Whittaker: "The Subcellular Localisation of Neurohormonal Agents".• (Further lecture on October 27.)

UNIVERSITY OF LONDON INSTITUTE OF EDUCATION (in the Great Hall, Goldsmiths' College, New Cross, London, S.E.14), at 5 p.m.—Mr. A. B. Clegg: "An Extra Year".• (Fifth of a series of lectures on "The Future of Education".)

UNIVERSITY OF LONDON (at Senate House, London, W.C.1), at 5.30 p.m.—Prof. C. H. Waddington, F.R.S.: "The Significance of Developmental Biology".• (First of fifteen lectures on "The Scientific Basis of Medicine", organized by the British Postgraduate Medical Federation.)

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. L. E. Akers: "The Manufacture and Properties of Wood Chipboards".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the SOUTH-EAST ESSEX TECHNICAL COLLEGE SCIENTIFIC SOCIETY, at the South-East Essex Technical College, Longbridge Road, Dagenham, Essex), at 7 p.m.—Dr. G. I. P. Levenson: "Some Chemical Aspects of Colour Photography".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Opening Meeting of the 54th Session. Dr. Telford Work will show a film entitled "Kyasanur Forest Disease in India".

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 8 p.m.—Mr. J. W. D. Bull: "The History of Neuroradiology" (Presidential Address).

UNIVERSITY OF LONDON (at Wye College, Wye, Ashford, Kent), at 8 p.m.—Sir Eric Ashby: "Reflections on Soviet Education".•

Friday, October 21

PHOTOELECTRIC SPECTROMETRY GROUP (in the Department of Chemistry, Imperial College of Science and Technology, London, S.W.7), at 2 p.m.—Meeting on "Recording Ultraviolet Spectrophotometers".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. S. H. Clarke: "Fire Research".

Saturday, October 22

BIOCHEMICAL SOCIETY (at the National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W.7), at 10.25 a.m.—Scientific Papers.

WORKERS' EDUCATIONAL ASSOCIATION (at Mullard House, Torrington Place, London, W.C.1), at 2 p.m.—Meeting on "Science and the Arts".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the date mentioned:

HEAD (graduate, with good industrial and teaching experience) OF THE ENGINEERING DEPARTMENT (Civil, Electrical and Mechanical Engineering)—The Acting-Principal, Dudley and Staffordshire Technical College, Dudley (October 21).

SENIOR LECTURER/LECTURER (preferably in possession of a medical qualification and also a higher degree) IN PHYSIOLOGY—The Secretary, London Hospital Medical College (University of London), Turner Street, London, E.1 (October 21).

SENIOR LECTURER (with high qualifications and wide experience) IN PHYSICS to teach to honours degree level; and an ASSISTANT, Grade B, IN PHYSICS—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (October 21).

LECTURER IN STATISTICS—The Registrar, University College of North Staffordshire, Keele, Staffs. (October 24).

RESEARCH FELLOW IN ORGANIC CHEMISTRY to work on the study of factors affecting polymerization of compounds containing boron–nitrogen bonds—The Registrar, The University, Nottingham (October 29).

SCIENTIFIC OFFICER (with a first- or second-class honours degree with physical or inorganic chemistry as the principal subject) IN THE DEPARTMENT OF PEDOLOGY, for work which will involve investigations upon soil formational processes with a physico-chemical bias—The Secretary, The Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (October 29).

ASSISTANT LECTURER or DEMONSTRATOR IN PATHOLOGY—The Registrar, The University, Manchester (October 31).

CHAIR OF MATHEMATICS—The Registrar, The University, Hull (October 31).

LECTURER IN THE UNIVERSITY COMPUTING LABORATORY, Newcastle upon Tyne—The Registrar, University of Durham, 46 North Bailey, Durham (October 31).

LECTURER or ASSISTANT LECTURER (qualified in pure or applied mathematics) IN MATHEMATICS—The Registrar, University College of North Staffordshire, Keele, Staffs. (October 31).

FELLOW (with field and laboratory experience in virology and the epidemiology of insect-transmitted viral diseases) IN THE DEPARTMENT OF MICROBIOLOGY, John Curtin School of Medical Research, Australian National University, to work on the epidemiology of arthropod-borne virus infections in Australia and the islands to the north of Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, November 4).

LECTURER (with qualifications in pure mathematics) IN MATHEMATICS—The Secretary, The University, 38 North Bailey, Durham (November 12).

RESEARCH DEMONSTRATOR (preferably with experience and interest in field and soil mycology) IN MYCOLOGY IN THE DEPARTMENT OF BOTANY—The Registrar, University College of North Wales, Bangor, North Wales (November 14).

SENIOR ASSISTANT LIBRARIAN (preferably aged 25 to 35 with a good knowledge of chemical literature and experience in an industrial or other special library)—The General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1 (November 14).

CHAIR OF CHEMISTRY, and a READER IN PHYSICAL CHEMISTRY AT THE UNIVERSITY OF KHARTOUM—The Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 15).

LECTURER (with an honours degree in zoology) IN ZOOLOGY AT THE UNIVERSITY OF CANTERBURY, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, November 15).

READER OR SENIOR LECTURER OR LECTURER IN AGRICULTURAL BIOCHEMISTRY; and a READER OR SENIOR LECTURER OR LECTURER IN ENTOMOLOGY IN THE FACULTY OF AGRICULTURE, University of Khartoum—The Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 15).

ASSISTANT LECTURERS (2) IN THE DEPARTMENT OF BIOCHEMISTRY—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (November 19).

CHAIR OF GEOGRAPHY AT THE LONDON SCHOOL OF ECONOMICS—The Academic Registrar, University of London, Senate House, London, W.C.1 (November 21).

CHAIR OF PSYCHOLOGY—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (November 26).

LECTURER/SENIOR LECTURER and a LECTURER (with research and teaching experience in some branch of pharmaceutical chemistry) IN PHARMACY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, November 26).

CHAIR OF PHILOSOPHY—The Registrar, The University, Hull (November 30).

LECTURER IN PSYCHOLOGY at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, November 30).

LECTURER (preferably with special qualifications in physiology or genetics) IN BOTANY at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, November 30).

ASSISTANT LECTURER, Grade "B" (with a good honours degree or equivalent with some teaching and/or industrial experience, and an interest in research) IN CHEMISTRY, to specialize in inorganic or physical chemistry to Grad.R.I.C. and B.Sc. General standard—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham.

BIOLOGIST (with a good degree in physiology or zoology and considerable research experience, preferably with spermatozoa) to join a small research team investigating cervical mucus, with particular reference to problems of fertility—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 60/13.

GEOLOGISTS (with a degree of a recognized university with either first- or upper second-class honours in geology, two years approved postgraduate experience, and preferably some specialization in mining geology) IN THE GEOLOGICAL SURVEYS DEPARTMENT, Federation of Malaya—The Recruitment and Personnel Division, Malaya House, 57 Trafalgar Square, London, W.C.2.

HEAD (medical graduate or science graduate with a higher degree) OF THE DIVISION OF VIROLOGY, for duties which include the supervision of diagnostic services and the carrying out of special investigations on and research into virus diseases—The Director, Institute of Medical and Veterinary Science, P.O. Box 14, Rundle Street, Adelaide, South Australia.

MICROBIOLOGIST (previous medical experience not essential) IN THE BACTERIOLOGY LABORATORY OF THE DEPARTMENT OF CLINICAL PATHOLOGY—The Administrator and Secretary, University College Hospital, Gower Street, London, W.C.1.

POSTDOCTORATE FELLOWS IN BIOCHEMISTRY, CHEMISTRY, ENGINEERING AND METALLURGY, PARASITOLOGY, PHYSIOGRAPHY, PHYSICS OR TEXTILES—The Personnel Officer, Ontario Research Foundation, 43 Queen's Park Crescent, Toronto, Ontario, Canada.

PROFESSORS (preferably with Ph.D. or M.Sc.) OF PHYSICS, CHEMISTRY, and BIOLOGY at the Medical College, Mosul, Iraq—The Director, Recruitment Department, British Council, 65 Davies Street, London, W.1, quoting N.14.N(60).

RESEARCH ASSISTANT (graduate in biochemistry, chemistry or physiology) for research on metabolic disturbances in neurosurgical patients—Dr. H. M. B. Buckell, Department of Pathology, Atkinson Morley's Hospital, Copse Hill, Wimbledon, London, S.W.20.

RESEARCH FELLOWS IN PHYSICS for research on optical and electronic instrumentation for high energy physics in connexion with the experimental programme of the 7 GeV. Synchrotron at the Rutherford Laboratory, Harwell—Prof. G. W. Hutchinson, Department of Physics, The University, Highfield, Southampton.

TECHNICIAN to cut and stain histological sections in connexion with a research programme IN THE DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY—The Assistant Bursar, The University, Reading.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Planning, Vol. 26, No. 442 (June 1960): Division in Europe. By Miriam Camps. Pp. 137–204. (London: Political and Economic Planning, 1960.) 6*s.* [197

Department of Scientific and Industrial Research. Report of the National Chemical Laboratory 1959: Report of the Steering Committee for the period 1st October 1958 to 31st December 1959, and Report of the Director of the National Chemical Laboratory for 1959. Pp. iv+72. (London: H.M. Stationery Office, 1960.) 4*s.* 6*d.* net. [197

Scientific Council for Africa South of the Sahara. Publication No. 35: Mental Disorders and Mental Health in Africa South of the Sahara—CCTA/CSA—WFMH—WHO Meeting of Specialists on Mental Health, Bukavu, 1958. Pp. 269. (London: Joint Secretariat, Scientific Council for Africa South of the Sahara, 1960.) [267

Planning, Vol. 26, No. 443 (25 July 1960): Government by Appointment. Pp. 205–228. (London: Political and Economic Planning, 1960.) 3*s.* 6*d.* [267

Department of Scientific and Industrial Research: Geological Survey and Museum. British Regional Geology. Scotland: The Northern Highlands. By Dr. J. Phemister. Pp. vii+104+8 plates. (Edinburgh and London: H.M. Stationery Office, 1960.) 5*s.* net. [267

Department of Scientific and Industrial Research. Hydraulics Research 1959: The Report of the Hydraulics Research Board with the Report of the Director of Hydraulics Research. Pp. iv+67+8 plates. (London: H.M. Stationery Office, 1960.) 5*s.* 6*d.* net. [267

Department of Agriculture for Scotland. Memoirs of the Soil Survey of Great Britain. Scotland. The Soils of the Country Round Kelso and Lauder (Sheets 25 and 26). By J. M. Ragg. Pp. 201+28 plates. (Edinburgh and London: H.M. Stationery Office, 1960.) 35*s.* net. [267

University of Bristol. The Annual Report of the Agricultural and Horticultural Research Station (The National Fruit and Cider Institute), Long Ashton, Bristol, 1959. Pp. 172+10 plates. 15*s.* Members' Supplement to the Long Ashton Annual Report 1959. Pp. 8. (Long Ashton, Bristol: Agricultural and Horticultural Research Station, 1960.) [267

Bulletin of the British Museum (Natural History). Geology. Vol. 4, No. 6: Plant Remains of the Hengistbury and Barton Beds. By Marjorie E. J. Chandler. Pp. 191–238+plates 29–35. (London: British Museum (Natural History), 1960.) 30*s.* [267

Ciba (A.R.L.), Limited. Technical Notes No. 211 (July, 1960): Epoxy Resins for the Electrical Industry. By H. Davies. Pp. 8. (Duxford: Ciba (A.R.L.), Limited, 1960.) [267

Air Ministry: Meteorological Office. Geophysical Memoirs No. 104: The Exchange of Energy between the Atmosphere and the Oceans of the Southern Hemisphere. By D. W. Prevett. Pp. 61. (M.O. 631d). (London: H.M. Stationery Office, 1960.) 8*s.* 6*d.* net. [267

Other Countries

Instituto de Investigacao Cientifica de Mocambique. Novos Taxa Entomólogicos. (Supplemento à *Revista de Entomologia de Mocambique*.) No. 16: A Revision of the Lycaenid genus *Durbania* Trimen, with the description of Two New Genera and Two Subspecies. By G. Van Son. Pp. 15+1 plate. No. 17: Alguman Novas Espécies de Tabanideos (Diptera: Tabanidae) da Africa Portuguesa. Por J. A. Travassos Santos Dias. Pp. 12. No. 18: Descricao de Duas Novas Espécies de Tabanideos (Diptera: Tabanidae) da Guiné Portuguesa. Por J. A. Travassos Santos Dias. Pp. 9+1 plate No. 19: The Tenebrionidae of Southern Africa. 28: On a New Faunistical Link Between the African Continent and the Cape Verde Islands (*Ammidium Erichson*). By C. Koch. Pp. 15+1 plate. No. 20: New Fleas. (Siphonaptera) from Central African Gerbils, with Notes on the Taxonomic Status of their Hosts *Tatera leucogaster* and *T. taborae*. By Tilly Marcus, Botha de Meillon, and David H. S. Davis. Pp. 8. No. 21: Mais uma Nova Espécie do género *Haematopota* (Diptera: Tabanidae) de Mocambique. Por J. A. Travassos Santos Dias. Pp. 6. No. 22: New Siphonaptera from the Subsaharan Geographical Region. By Tilly Marcus and Botha de Meillon. Pp. 8 (2 plates). (Lourenco Marques, Mocambique: Instituto de Investigacao Cientifica de Mocambique, 1959 and 1960.) [267

Chicago Natural History Museum. Fieldiana: Botany. Vol. 30, No. 3: Orchids of Peru. By Charles Schweinfurth. Pp. vi+533–786. (Chicago: Chicago Natural History Museum, 1960.) 4.50 dollars. [267

Immuno Biologia de la Equinococcocis. Por Dr. Carlos Perez del Castillo. Pp. 71. (Montevideo, Uruguay: Dr. Carlos Perez del Castillo, Solano Antuna 2908.) [267

Deutsches Hydrographisches Institut, Hamburg. Jahresbericht Nr. 14 für das Jahr 1959. Pp. 83. (Hamburg: Deutsches Hydrographisches Institut, 1960.) [267

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